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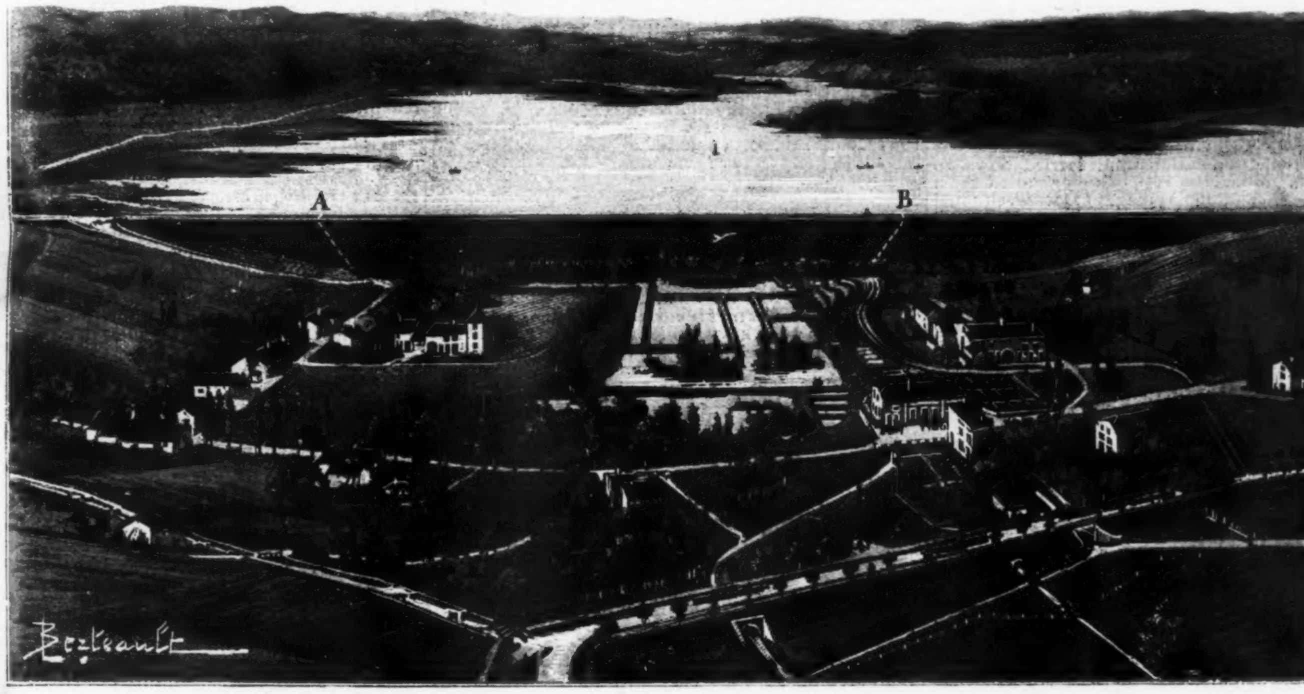


THE BOUSEY RESERVOIR AND DAM PRIOR TO THE CATASTROPHE
A and B indicate the points where the dam gave way.

BURSTING OF THE CANAL RESERVOIR OF BOUSEY, FRANCE.

BURSTING OF A DAM IN THE VOSGES.

A VERY serious disaster took place in the Vosges. A dam holding in check an immense reservoir of the Eastern Canal at Bousey, near Epinal, broke down on Saturday morning, April 27, 1895, at 5:30, for a distance of some 300 feet. The torrent of water thus set free swept through Bousey, Aviere, Uxegney, and Sanchey, carrying all before it, and washed away portions of the railway lines of Jussey and Nancy. Many bridges were carried away. The number of victims is given as 117.

The disaster overwhelmed a large tract of country between Epinal and Chatel, 11 miles to the north. The great rush of water into the canal put such a strain on the banks that they too burst above the village of Bousey, and the whole of the water contained in this section of the canal, over six miles in length, poured down with the torrent from the reservoir, until the whole section from the lock above the breach to the lock below had been emptied. Had the water been able to spread over any great extent of level country, the disaster would not have been so serious, but the Epinal region is almost mountainous, and the water, hemmed in on either side by high hills, tore down the narrow valley in a huge wave, carrying away buildings, bridges, trees, and even whole plantations, and finally emptying itself into the Moselle at Nomexy and Chatel.

Several villages situated in the valley of the Aviere were inundated. In some places houses were swept bodily from their foundations and carried down to lower levels; at others the rush of water caused them to collapse on the spot. The village of Bousey, situated directly below the reservoir, was completely destroyed, together with a large fish breeding establishment situated almost on the banks of the reservoir. Not a house in the place is left standing. At Les Forges, a place of 1,400 inhabitants, only a few houses remain. At Uxegney, a village of 600 inhabitants, 23 persons were drowned. At Darnieulles, the next village, containing 600 inhabitants, every building was swept away. At Nomexy also a number of the inhabitants perished, and although this village is situated at the extreme northern end of the desolated valley, at the spot where the Aviere pours into the Moselle, and is distant nearly ten miles from the broken dam, the rush of the water was so sudden that many were caught before they could either reach higher ground or get into the upper stories of the houses. At Domevre 17 houses were destroyed and 25 of the inhabitants were drowned. At Oncourt three houses collapsed, while one life was lost. According to information from Uxegney, 17 persons are missing and 16 houses have been carried away.

The whole of the Aviere valley presents a scene of utter desolation. The region is strewed with the bodies of sheep, cows, and other live stock. The Aviere rivulet, which in its normal state is only about two and a half yards broad, has been converted into a vast lake a mile and a half in breadth. The railway, especially in the neighborhood of Darnieulles Station, has been torn up and swept away, the rails being scattered at a distance of ten or a dozen yards from their former position, while the embankments have been carried away bodily.

The total damage is roughly estimated at over 50,000,000 f. The government and municipal officials are distributing relief throughout the district.

The Bousey reservoir contained seven million cubic meters of water. The dam, which was constructed between 1879 and 1884, and was strengthened in 1888-89, was 60 feet thick at the base. It was constructed of strong masonry and the stonework was carried into the ground to a depth of 30 ft. below the level of the valley into which the reservoir discharged its waters.

'EDUCATIONAL PROGRESS AMONG THE BLACKS OF THE SOUTH.

By J. R. PRESTON, Superintendent of the Public Schools of Mississippi.

NO people ever had such a problem to work out as that now pressing upon the Southern people. They had that mass of black ignorance thrown on them, to live with side by side under new conditions, and to educate and transform in some way so that they would be fit to associate with under the new conditions, and so that the race could emancipate itself. The proportion of the races is seven to six in favor of the blacks throughout the South, and in some counties in Mississippi they are eight to one—yes, sixteen to one. And that one per cent. of white people own all the property in that country excepting about ten per cent., and yet they keep public schools open eight, nine and ten months in the year for all those black children.

There is not a white teacher in a black school in the State. They have settled that by race instinct or race judgment themselves, though some white teachers would take the black schools if we would let them. The blacks want their own teachers. They like it better, and it makes a professional field for the ambitious of their race—the only one they have. The colored teachers occupy the most important position and are the most looked up to of any members of the race. It gives them a pre-eminence even over the preachers. For this reason there are more men teachers than women among the colored people. It is the best field the men have and they crowd into it.

These teachers are examined by a white board. They have just the same questions that the white teachers have. I make them out and I know. In 1886, when I gave my first examination, there were 123 Negroes in the State that passed a first grade examination. At the last examination there were 606 that passed the examination and are holding first grade certificates. And the board was just to them and gave them all they earned, but it isn't likely to err on the side of mercy.

We keep up normal schools and colleges and summer institutes for them. White men go out and hold the institutes; we never mix the teachers of the two races in the institutes, though the other day I was conducting an institute where there were nineteen colored teachers in attendance, and I found that eighteen of them were college graduates I went right over into an adjoining county and took a white institute with thirty-seven in attendance, and found only about one-fourth were college graduates. But this is an experiment.

The Negro race is a race that has never evolved a civilization; they have never constructed a city—never built up a commerce — never written a literature, hardly a book. When you try to give to such a race just the same education that you give to the race that has done all these things—why, it's an experiment. That's all you can say. The South is trying the experiment, trying it faithfully. How it will turn out I don't know.

The race is very anxious to acquire book education. It gives them importance in their own race, and it opens the door of teaching to them. Some of them do very well. I visited a school just the other day; a school of about 500 children, with a Negro woman as principal. It was splendidly conducted, good discipline, good progress, everything ship shape. And that woman conducts herself with so much dignity and possesses such a fine character and is so competent in her profession that she has the respect of everybody in that town, black and white; just commands it, you see; they can't withhold it. Yes, it's an experiment. You can't tell how it's going to turn out, or what's going to come of it all.

A peculiar feature of the school question in my State is that there are 230,000 white children and 330,000 colored children in the State. Sixty per cent. of the colored and 72 per cent. of the white children attend the school, so that the number of colored children in schools is greater than the number of whites.—The Independent.

RELICS OF NELSON SOLD.

A QUANTITY of silver and silver gilt plate, and a number of gold boxes, medals, gold sword hilts, and other articles formerly in the possession of Lord Nelson were sold at Christie's on July 12, and most of them brought very high prices. The 11 medals and orders worn by Lord Nelson when he was killed at Trafalgar were withdrawn from the sale, having been bought by the government, at the price, it is understood, of £2,500. Of the articles sold on Friday, the highest amount was paid for a brilliant necklace, consisting of the stones removed from the sword of honor presented to Lord Nelson by the King of Naples—£1,250; the gold sword hilt itself realized £170; an aigrette of rose diamonds, presented to Lord Nelson by the Sultan of Turkey after the battle of the Nile—£710; Lord Nelson's inkstand, inscribed "William and Emma Hamilton to Nelson, Duke of Bronte, their dear friend," was knocked down to Lady Llangattock for £520; its weight is only 17 oz. An oval gold box, presented to Lord Nelson with the Freedom of the City of London, reached £1,050. The gold sword hilt presented by the Captains of the Fleet, after the battle of the Nile, sold for £1,080. An oblong ivory patch box, with a plait of Lord Nelson's hair, in gold border, went for £45 to Lady Llangattock; the combined gold fork and knife used by Lord Nelson with steel edge presented to Nelson by Countess Spencer at the time when Earl Spencer was First Lord of the Admiralty—£260; a brooch of pastes which formed the fastening to the "cloak of honor" presented to Nelson by the Sultan of Turkey realized £260.

On Monday a small casket of jewels, lace, miniatures, fans, watches, old French boxes, etc., from a number of private sources, came under the hammer at Christie's. Perhaps the most interesting article was the remarkable musical repeating watch of unusual size, with seven dials, central hand showing fifths of seconds, in a case of metal gilt covered with plates of gold chased with festoons of flowers and inlaid with oval plaques of crimson enamel and medallions painted with musical and pastoral trophies on white ground, the borders set with pearls, with the inscription—"Presented to Admiral Lord Nelson by the officers of H. M. S. Victory, August 20, 1805." This most interesting relic realized 40 guineas.—London Times.

EXPERIMENTAL PSYCHOLOGY.

By E. B. TITCHENER, A.M., Ph.D., F.Z.S., Assistant Professor of Psychology and Director of the Psychological Laboratory at Cornell University, Ithaca, N. Y.; Member of the Neurological Society of London and of the American Psychological Association.

IN the list of the instructors at any of the principal American universities will be found some name with the title "Professor of Experimental Psychology," or "Director of the Psychological Laboratory." Those are curious titles. Fifty years ago they would have been as unintelligible and impossible as the titles "Professor of Experimental Logic" or "Director of the Theological Laboratory" would be to day. The nineteenth century has seen the doing of many wonderful things; but surely nothing is quite so strange or wonderful as this—the construction of laboratories in which the material experimented on is the human mind.

For it is mind that the psychologist is busied with. Psychology is the science of mind. Everyone knows what mind means; or, at least, everyone uses the word quite commonly in conversation. People say: "I cannot make up my mind." It is that which they cannot make up that the psychologist experiments upon. Or they say: "I have half a mind to do it." Or again, if they are in doubt about something, and ask a friend for advice, they may be told: "Look into your own mind, and do what it tells you." And we are accustomed to characterize a person as strong-minded or weak-minded, as possessing a logical mind, or a quick mind, or an acute mind and so on. Mind, in all these senses, is the subject of the psychologist's study.

But that, of course, is mind in the rough. One cannot begin to work upon mind, in that sense, without further preparation. Let me give an illustration. Physics deals with the properties of matter—of the bodies of the world outside us. And the physical laboratory is fitted up in a way that enables the student to experiment upon natural bodies—liquids and solids and gases. But when he enters a physical laboratory he does not find there a collection of natural bodies. He finds a number of special instruments—inclined planes, and pulleys, and wedges, and pumps, and so forth. It is by their aid that he is introduced to the study of natural bodies; and his study would not be scientific if he dispensed with them. So with physiology. In the physiological laboratory he is taught to examine the functions of the various animal organs; the uses of the heart, and the muscles, and the nerves. But when he enters the laboratory, he does not find a flock of sheep waiting to be worked upon. He finds, again, a collection of special, technical instruments; and he works with a single bit of muscle, or a single strand of nerve, by the aid of those instruments. Just the same rules obtain in psychology. When the student comes into the laboratory, he is not set to work upon mind as a whole; but at some particular little bit of mind, some special mental process. That is the technical phrase.

But how does one get to these "bits" of mind? How is this cutting up, which seems to be a necessary preliminary to scientific work upon mental phenomena, accomplished? Why, that is not so very difficult. One only has to go to language, and ask it for help, and the thing is done. Language is fossil mind. When we talk, we do so in order to give expression to something that is in our mind. Words are symbols, standing for different bits of mind; and we only have to go and quarry among these symbols to dig out any number of separate fragments, which we can then set to work upon in the laboratory. Language distinguishes one set of mental states as emotions. Such are anger, fear, hope. It distinguishes others as feelings, pleasures and pains. It distinguishes others as sensations: such would be blue, hot, sweet, heavy. It distinguishes others as desires, thoughts, instincts, ideas, and so on. So that mind with which we started out as a whole is split up by an appeal to language into a large number of separate mental states or mental processes. To the psychologist, mind is simply the sum total of all those mental states that language has marked off—thoughts, feelings, desires, perceptions, wishes, moods, sentiments, and all the rest. Those states constitute the material of his investigation.

Now, it is a rule of scientific inquiry to begin with the simple, and not go on to deal with the compound till we have learned all that we can learn of that. Begin with the easy, and then later proceed to the difficult. That is done in chemistry; we begin with the elements—oxygen and hydrogen, and the like. It is done in biology; we start out with the most rudimentary animals—those that consist of only a single cell—and gradually take more difficult forms of life, till we come last of all to the most complex form that there is—man. Psychology must follow the same rule. We must begin with very simple states of mind, and travel by slow degrees from them to the more complex and difficult. And a little reflection shows us that the most simple mental states that we experience are our sensations. The emotion of anger is plainly complex: it contains the idea of the person who has made one angry; the idea of the act of his, at which one is angry; the idea of what his action should have been, of what he ought to have done if one was not to be angry; it contains a sense of personal injury; there is an uncomfortable feeling in it, a feeling of discomfort and uneasiness; and there is contained in it, also, the wish to be oneself again, to be rid of one's uncomfortableness. We cannot possibly, then, begin to study mind by way of emotion. An idea, again, is a compound state. My idea of a house contains many sensations of color; many perceptions of form and outline; as well as a feeling of approval or disapproval of its beauty or ugliness. But the sensation is something different. We cannot split that up into other states. The sensation of blue; what can be simpler than that? Blueness cannot be resolved into so many ideas and feelings; it is just itself, and we cannot go behind it. So the sensation of sweet. You cannot say that it is composed of any other states; it is not a mixed state of mind, it is an ultimate and irreducible experience. So the sensation of heaviness, of pressure on the skin; or the fragrance of a rose, the sensation of smell; they are last things of mind, states at which inquiry stops short, beyond which analysis cannot go.

It will now not be surprising if I say that, when the student goes to work in a psychological laboratory, the first thing that he is set to study is sensation. He is put through a drill course in sensation before he is allowed to take in hand the higher mental states, like emotion, or memory, or attention. At the same time there may be some hesitation in accepting the statement that sensation is a matter for the psychologist to investigate. Does not the study of sensation, it may be asked, belong by rights to the physiologist? Do we not find discussions of sensation in every physiological text book? Cannot psychology accept the results of physiological research, instead of starting fresh on her own account? Those are all fair questions. But I think that I can show by a very simple illustration that there is work for the psychologist here, and that he is not trespassing on the physiologist's domain when he undertakes it.

For us to experience a sensation of any kind, it is necessary that a particular bodily organ be thrown into activity. We can only see if our eye is in activity; we can only hear when our ear is active; we can only taste if some sort of impression from outside affects the tongue. Now, these organs of sense are machines or instruments, just like the physical machines and instruments that we have around us to assist us in our ordinary employments. Suppose we compare the ear, for instance, to such an instrument, we will say a piano. A piano is a single instrument, but it is made up of a large number of separate parts. There are so many pieces of ivory of a certain shape, so many pieces of wood of a certain shape, so many pieces of wire of certain lengths and thicknesses, so many pieces of felt of certain forms and thicknesses. One way, then, of describing the piano would be to enumerate all these various parts, giving exact details as to blemishes or excellences. It would be a long and wearisome way, but it is a distinctly possible way. But now all these parts of the piano, which we will suppose to have been described, are, in the instrument itself, grouped together, held together in systems, by hinges and levers and screws. One system would consist of the c string, with the felt-headed hammer that strikes it, the lever connecting the hammer with the ivory note, this note c on the keyboard itself, and the part of the damper that works upon the c string. There are some eighty-five of these systems in the instrument. Plainly, an-

other way of describing the piano would be to give an account of one of these systems: to say that it consists of a number of pieces put together for a particular purpose, and to state what this purpose is. Instead of giving details as to the defects or excellences of the various bits of wood or metal or ivory, the describer would state the defects of the system, or its advantages, with reference to the work which it had to do. He would say that the systems in the base did not work, because the wires were badly strung; that particular notes could not be sounded, because the hinges were jammed, and so on. This description would be different altogether from the first one, but it would be a good description from a certain point of view. And now, lastly, a third description might be given in terms of the tones which can be got from the piano. One might say that it was mellow in tone, or that its tone was metallic; one might say that the base chords were richer than the treble; or, going into details, one might calculate out how many tonal combinations it was capable of producing, or ask how its tone differs from the tone of the organ or the trumpet, which are also musical instruments. Apply all that to the ear. The same three standpoints are possible. The man who enumerates and describes all the separate parts of the ear is the anatomist. The man who describes the ear in regard to its purpose or function is the physiologist. He will tell us what all the anatomical portions of the ear are for, and whether they are well or ill adapted to their purpose; he will tell us how the ear works, when a vibration of the air outside of it throws it into activity. The man who pays attention to the sensations of hearing, who asks how many different tones the ear can appreciate, how all these various tonal sensations combine in the mind when they are given together, what it is that marks off in the mind the note of a trumpet from the note of a clarionette, how it is that some tonal sensations and combinations of them are pleasant and some unpleasant—that man is the psychologist. The anatomist finds that there are enough pieces in the ear to allow of the construction of systems for 11,000 tones. The physiologist finds that there are 11,000 working systems for tones, if the ear is normal. The psychologist finds that we can have 11,000 distinct sensations of hearing. But music uses less than 100 of those 11,000. There is a further problem for the psychologist. Why is it that music does not employ more tones? Why, of all the possible tones, does she employ just these that are given by the various musical instruments, and not another set of tones altogether? These questions can only be answered by an examination of the mutual relations existing between tonal sensations in the mind. In a word, after the spheres of anatomy and physiology have been traveled through and left behind, there is another domain before us, demanding exploration, the territory of psychology.

That, I hope, is a satisfactory answer to the objection that I imagined to be made just now, the objection that the study of sensation belongs to physiology, and not to psychology. It is plain that the student can be put through the drill course that I mentioned in a psychological laboratory, and be kept strictly *within* the bounds of psychological investigation. And now, enough having been said by way of introduction, I can go on to tell something of what a psychological laboratory actually looks like, and of the problems that are worked at there.

If I were showing a visitor my own laboratory, I should take him first of all into the acoustic room. In that room he would find all manner of sound, or rather tone, producing instruments. He would find organ pipes; tiny whistles, carefully constructed to tell how many vibrations in the second the air wave that strikes the ear is making; he would find a piano; strings and bows to sound them with; he would find chests containing metal tongues of different lengths, which can be set vibrating by a draught of air; blocks of wood which give different notes when one strikes them; steel rods which give deep base tones when one sets them swinging; and above all he would find tuning forks; tuning forks on resonance boxes, that boom all through the room when they are struck, and little hand tuning forks, that will give the full chromatic scale, but are so faint that they must be held close up to the ear to get the tone; tuning forks whose tones are thousands of vibrations in the second apart from one another, and series of forks whose tones differ from each other only by a fraction of a vibration; tuning forks that are as tall as he is himself, and tuning forks whose prongs are so short that they are hardly anything more than little knobs of metal side by side at the top of the handle. All these instruments we employ to answer the questions which I spoke of a moment ago; the range of hearing sensations (anything between the rates of 16 and of 50,000 vibrations in the second can be heard); the capacity of the ear to discriminate between very similar tones; the manner in which simultaneous tones blend and combine in the mind to form single ideas; the laws of the musical scale; the mental process by which we hear an organ tone as different from the tone of a flute, and so on. All that would form a part of the student's drill course in sensation. Then I should take my visitor into the optical room. There is a quite similar collection of instruments. We have instruments for determining of how many sensations of light and color the eye is capable; there are about 40,000 of them. Others show how visual sensations are modified by the presence of other sensations in the mind; these are the phenomena of color harmony and color contrast. Others show how the form and size of visual sensations are affected by the various possible eye movements. Others again measure the eye's power of discriminating between sizes and forms that are very nearly alike. Others demonstrate how long the sensation lasts, and what its nature is, after the physical stimulus has ceased to work. Yet others show us how the sensations from the two eyes blend together harmoniously to give us a single perception, and so on. All these instruments and their uses have to be learned by the student of psychology. Then in another room we have apparatus for the investigation of the other senses. Thus for the sense of touch there is an instrument that carries a point over the skin at a constant rapidity, and in a constant direction. The point is moved up hill and down dale, over the surface of the skin, at a perfectly even rate; and the place that you have worked over to-day you can work over again to-morrow, without deviating by a hair's breadth from the old path. Then there are other instruments for giving simultaneous impressions of equal heaviness, on the skin. By their aid one can discover how good the skin is at estimating distances in space. You put down two points, an inch apart, with equal pressure, and after a moment's interval two different points, which are one and an eighth inch apart, and you ask whether the skin feels that one of the distances is longer than the other, or if it is incapable of discrimination of such a small difference. Then again there are delicately graduated series of weights, by the help of which we can tell how fine the discrimination of our muscles and tendons is, they being the organs involved, of course, when weights are lifted. And there are plenty of others. Lastly, we have apparatus for the examination of smell and taste and the temperature sense, although these are not by any means so elaborate or so perfect as those that I have mentioned hitherto. All of them must be mastered and tested by the student.

The first thing, then, that the beginner in experimental psychology has to do is to get a thorough knowledge of the sensations and of the laws which govern their appearance and the mode of their combination in mind. There is another branch of training which is not quite so elementary, but equally important. That is, training in what are called reaction experiments. I must say a few words about them.

The typical reaction experiment is very simple. The experimentee sits, we will say, in a dark room. Suddenly a light flashes out from the darkness. As soon as the observer has seen the light, he makes some movement; the movement is his response to the light, and has been agreed upon beforehand between himself and the experimenter. That is all—the execution of a definite movement in answer to a definite sense impression. But the way in which the experiment is controlled makes it valuable.

The instruments are always so arranged that the time elapsing between the giving of the impression and the performance of the movement in response to it can be measured. At the moment that the impression is given, an electric clock is set going; and at the moment that the movement is made the clock is stopped. The apparatus that gives the flash closes an electric circuit; the movement that answers to it breaks the connection of an electric key. The clock goes just for the few hundredths of a second between closing and breaking. Thousands—tens of thousands—of these time records have been taken, and we now know within a few thousandths of a second exactly how long it ought to take a man to execute a movement in answer to a flash of light, a sharp snapping sound, or the prick of an electric current sent into his skin.

The time values are important in themselves to one who knows how to interpret them. But for the beginner in psychological work they are of more importance in another direction, both in themselves and for what they tell his instructor about him. For instance, if a man's reaction time is too slow, and remains too slow in spite of practice, it is of no use to go any further with him in experiments upon the will or the attention; and so if the times are consistently too short, or if they are persistently irregular. Again, the instructor knows that the length of the reaction time will differ, according as the subject directs his attention principally to the sense impression or to the movement he is to carry out in response to it. He will therefore say: "In this set of experiments, attend as closely as you can to the flash, and never mind the movement." And at another time: "Attend to the movement, and do not trouble so much about the flash." If the experimentee is a person accustomed to control and examine his mind, if he is the stuff that psychologists are made of, he will be able to direct his attention as he is told; and the instructor can read off from the electric clock that the attention is going in this direction in this experiment, and in that direction in that. In this way he can sift out the attentive students from the scatter-brained almost at a glance: and that is no small advantage. On the other side, the student is benefited by reaction experiments in a way in which he cannot be by experiments on sensation—he has to learn to control his mind very accurately, to keep a tight rein over his attention, to concentrate himself and not follow up a distraction, to watch closely that he fulfill exactly the conditions of the experiment. No small advantage this to the student. For the reaction is the type of all action. In everyday life one has an idea and acts on it. In the laboratory one has a simple sensation and acts in a definite way upon that. The one case is exact, the other inexact; that is all the difference. To act resolutely, unhesitatingly, without flurry or precipitation, that is what is learnt from reaction experiments. And that is the second part of psychological drill work.

It is obvious, now, what the contents of another room in the laboratory will be. There will be instruments which give a sense impression, at the same time that they close an electric circuit. We have a large pendulum which sends a flash of light in this way; a set of electric hammers for giving sharp, short taps of sound; and instruments for sending a momentary electric current into the skin. Then we have all kinds of apparatus to regulate the movement made in answer to the impression; the reactor may answer by just lifting his finger off an ordinary telegraph key, or by opening out his thumb and finger, or by opening his lips, or by speaking a word into a funnel. And, thirdly, there are the electric clocks themselves, with instruments to test their accuracy, and other instruments to test the accuracy of those testing instruments. All this has to be understood theoretically, and handled practically, by the student who comes to work in the laboratory.

Those are the two sides of elementary laboratory work. The sensation drill teaches the beginner what it is necessary for him to know about the elementary processes of the mind, the very simplest bits of mind that we can reach; and at the same time gives him practice in handling instruments of precision. The reaction drill teaches him to get control of his mind, to make it do just what he wants it to do at the moment; it makes him steady and patient and reliable. When the student has got as far as this, he may be allowed to begin experimental psychology.

For so far we have hardly crossed the threshold into the science proper. One would hardly say that the student who had worked through an elementary arithmetic had "begun mathematics;" you do not really begin mathematics till you get to somewhere about the calculus. And it is the same here. The student of whom we have been talking has now obtained a base of operations from which to attack experimental psychology; but nothing more. We will suppose that he wishes to continue. What will he have to do?

Well! In general terms, it is easy to answer that question. His work will be the experimental examination of the more complex mental states. He may take up any kind of problem that he likes; his material may be ideas and their laws; or feelings and theirs; or memory; or imagination; or attention; or what not. What department of inquiry he chooses will depend upon his particular tastes and on what has interested him in the course of his reading and drill work. There are a certain number of classical experiments upon these higher mental processes which it is the instructor's duty to see that he repeats and understands; but, apart from them, he will be allowed to choose for himself what side of mind he devotes himself to especially. It may be thought that it is a little early for this freedom of choice, the drill course being only just concluded. But this must be remembered: If our particular student is to get others to serve as his experimental subjects, he must pay them back in kind, by letting them experiment on him. And as he will himself require some half dozen assistants in his own work, he will devote half a dozen hours a week of his own time to other investigations. So that there is no fear of his becoming prematurely one sided.

What are these special problems like? We will take the subjects that I named just now. First of all, ideas. One may work experimentally upon the problems of the association of ideas, as it is called. If I were to write up the word "pin" before a class upon a blackboard, and to ask my audience to read that word, and then to write down the first word that came up in their minds after they had read it, three-fourths of the women would write down "cushion," and three-fourths of the men "needle." Those words are very frequently connected or "associated" in their minds. Now there are several laws or rules of this association of ideas, and they can only be got at by experiment. Secondly, I mentioned feelings. It is a matter of ordinary experience that we find certain impressions pleasant and certain others unpleasant. We can make that fact the material of experiment. We can take a long series of colors, for instance, and expose them one by one, asking the experimentee to select those which are pleasant and those which are unpleasant. Or we can take a series of forms—rectangles, or ovals, or crosses—and expose them to the observer, and let him choose out the proportions that he finds most pleasing in them. In this way we shall discover whether there is one universal law—whether all of us like the same forms and colors, and dislike the same, or whether there are differences between one individual and another. That is what is called the serial method of experimenting upon the feelings. Another method, which is only just now beginning to be developed, is termed the expressive method. You present objects to the observer, or you place him in certain conditions, and you register the phenomena of expression, which indicate whether he is pleased or displeased with things. Thirdly I spoke of memory. We can make a person learn by heart a series of words, or of meaningless syllables, and call upon him to repeat them at some future time. The memorizing must be done by a definite number of repetitions; and the time of recall must be definitely fixed. Then we can tell what the laws of memory and forgetfulness are; what kind of words we remember best, and what kind worst; and by varying our experiments we can find out why these laws hold. As regards imagination. We can place the observer in a dark room, and tell him that at a particular place upon the black surface before him he will presently see a faint light. We ask him to state when he sees the light, and to describe his form and color. Many a student, sitting in this way in the dark chamber, has seen lights which do not exist outside of his own imagination. And these phenomena, curious as they are, have their laws like all the rest. Then, lastly, as to attention. We can inquire how many ideas the mind can attend to at one time; or how long it can attend without relaxation to a single idea; or what is the difference between the idea to which we attend and the idea to which we are inattentive; and what happens to an idea when we distract the attention from it; and so forth.

All these problems require special apparatus; and all this apparatus will be found in a well equipped psychological laboratory. We have particular instruments to study memory, under all its aspects; and particular instruments to study the attention. As for imagination, not only have we at Cornell an ordinary dark chamber, like the dark chambers that the photographers use, but within that we have built another smaller chamber, the darkness of which is such as may be felt. Until one has been in a chamber like it, one does not know what real darkness is; and when one does go in, one does not wonder that the unfortunate observer placed there should see in his mind's eye very strange things indeed.

That is the kind of work that the experimental psychologist is engaged upon. But as the concrete is always more interesting than the general, I will end by saying a word or two about the three principal pieces of work that we have done or are doing at Cornell. The first is this: We all know that the skin appreciates space, and we know that the eye appreciates space. Now, the two organs do not agree. Think how large the cavity of a hollow tooth feels to the tongue, and how small it looks. Think how large a blemish on the face feels to the finger, and how small it looks. There is a problem. In cases where both organs are involved in a space judgment, how are the two verdicts of size reconciled? We hope that we have solved that problem; at least, in part. The second is this: When we are reading the page of a book, we overlook misprints. If a letter is wrong, we still read it as right. Within what limits is this right reading of a wrong group of letters possible? Do we pay most attention to the shape of a word, neglecting the letters? Or do we look most at the first syllable, and overlook the rest? That is another problem at which we are working; and we have good hope of settling the questions involved. And the third is this: If we are doing anything under difficulties, if we are forcing our minds

upon it in face of distractions, we oftentimes do it better than we should had we been altogether comfortable and undisturbed during its performance. At the same time, if the distraction becomes powerful enough, we do the thing worse than we should have done, had we been undisturbed. Where are we to draw the line? What is the limit of favorable distraction? There again we are working, and working in good hope of an answer.

I hope now that I have made clear in what sense it is possible to experiment upon mind. Strange as the statement seemed when we first made it, it turns out to be perfectly rational and intelligible. The wonder is, as the wonder always is when a discovery is made, that this discovery of the applicability of the experimental method to the problems of psychology was not made till the middle of the present century. However, the psychologists try to make up for the youth of their science by the enthusiasm with which they pursue their investigations. And that students find the subject interesting is vouched for by the fact that within the last few years all the universities of note have found it necessary to establish "professorships of experimental psychology" and "psychological laboratories."—Medical Record.

THE DAIMLER GAS AND PETROLEUM MOTOR.

THE problem of designing and perfecting a motor for small and medium powers, for universal use, is one that has received a great deal of attention from engineers and inventors; but many failures have been made in attempts to meet all the requirements of the case.

The principal difficulty has been, not so much in the production of a working machine, as in designing a motor which is at once efficient, economical, safe, and capable of being used anywhere and by any one, whether experienced in mechanics or not. A machine having these qualities is shown in the annexed engravings. It is a new gas and petroleum motor, the invention of Mr. Gottlieb Daimler, the eminent engineer, Cannstadt, near Stuttgart, Germany.

These motors are built in sizes varying from one to ten horse power, and in several modified forms to adapt them to various uses, the small industrial motors being designed for convenient connection with machines requiring only a small amount of power, say less than one horse power, such as cream separating machines, sewing machines, pumps, ventilating fans, watchmaker's machinery, light woodworking machinery, and for the use of amateur mechanics.

The larger sizes of the industrial motor are suitable for driving dynamos, printing presses, elevators, grinding mills, etc.; while those adapted to boats and vehicles differ but little from those applied to other uses.

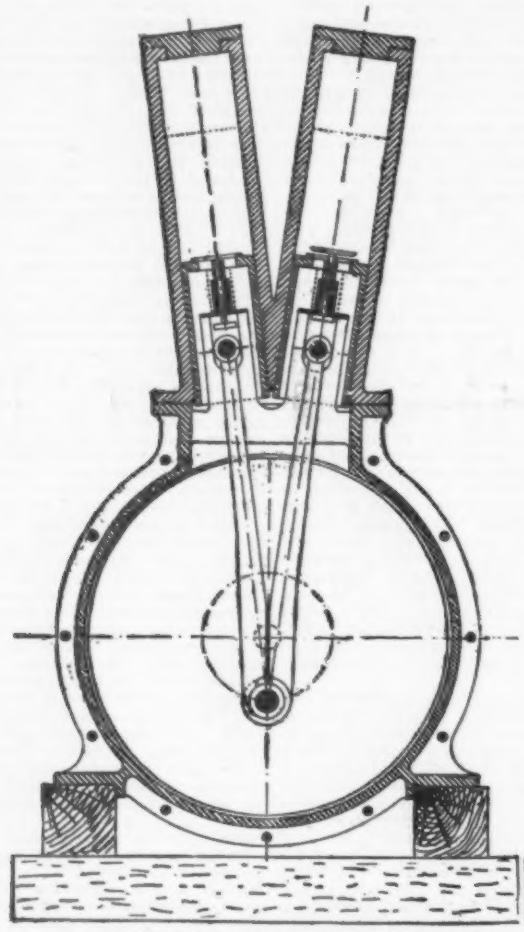


FIG. 1.—VERTICAL TRANSVERSE SECTION OF GAS AND PETROLEUM MOTOR.

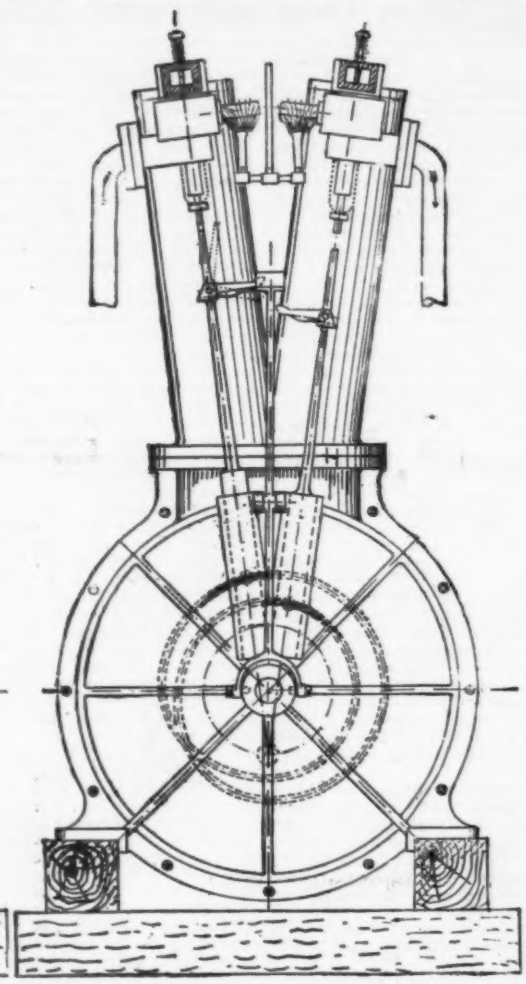


FIG. 2.—SIDE ELEVATION OF DOUBLE CYLINDER MOTOR.

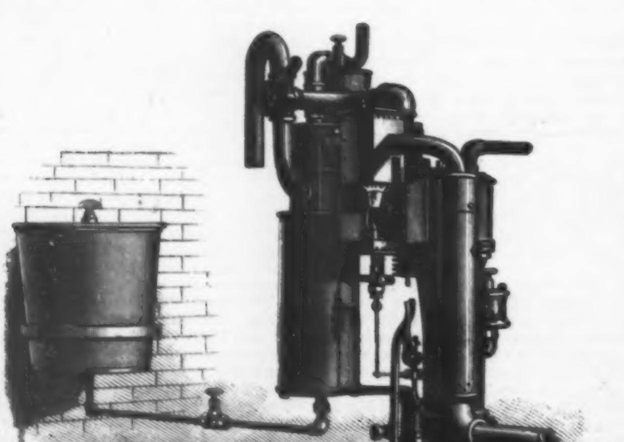


FIG. 3.—DAIMLER GAS AND PETROLEUM MOTOR.

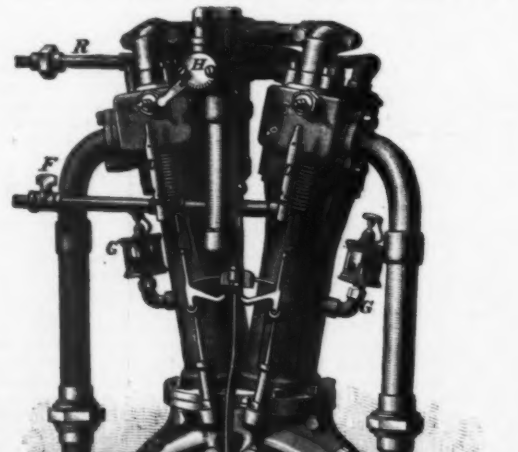


FIG. 4.—DOUBLE CYLINDER DAIMLER MOTOR.

Although these motors are built with a view to durability, with all the parts proportioned to safely stand the working strain, they are by far the smallest and lightest motors of their class. They are designed to run at a high speed, and are arranged so that they can be started in less than a minute, and may be run independently of either gas or water mains. When operated by petroleum gas, they run with still greater economy than with ordinary illuminating gas.

These motors are preferably made vertical, to economize space and reduce friction. In our engravings, Fig. 1 is a vertical transverse section of a double cylinder engine; Fig. 2 is an exterior view of the same; Fig. 3 is a perspective view of a single cylinder engine; Fig. 4 is a similar view of a double cylinder engine; Fig. 5 is a vertical section taken on a plane at right angles to the plane of Fig. 1; Fig. 6 is a diagrammatic view of the gas-producing apparatus; and Fig. 7 is a perspective view, showing the application of the motor to a boat.

The base of the motor consists of a cast iron gas-tight, circular chamber, with a valve inlet for combustible mixture or air. In the base are placed two disks, mounted upon the two sections of the main shaft and connected by a crank pin, the disks serving the double purpose of a crank and fly wheels. In one of the disks is formed a double slip-cam groove, which passes twice around the crank shaft and returns into itself. In this cam groove is placed a follower, which operates the valve gear so as to make every alternate stroke a working stroke.

Upon the base are mounted one or more working cylinders, according to the power required. When two cylinders are used, they are either arranged parallel with each other or joined at the base so as to spread out at the top, forming a slight angle, as shown in Figs. 1, 2 and 4. Each cylinder contains a piston furnished with a valve for the transfer of air or gaseous mixture from the base, the valve being provided with a fork by which it is operated. It will be observed by reference to Fig. 1 that both the connecting rods of both pistons in the double cylinder engine are received upon the same crank pin. The space in the upper end of the cylinder above the piston is the explosion chamber, with which are connected the inlet and exhaust valves. All the valves used in this engine are of the type known as poppet valves, these having been found in actual practice preferable to sliding or rotating valves. Every alternate stroke of the piston is a working stroke. During the upstroke of the piston, following the working stroke, a preliminary charge of air is drawn into the lower part of the working cylinder, from the crank chamber in the base, as the piston rises. At the same time, the upward movement of the piston forces the products of combustion from the explosion chamber through the exhaust valve, which is opened by the slip cam. During the following downstroke the air in the cylinder below the piston is forced upwardly into the working part of the cylinder. At the same time a charge of combustible gas is admitted, and the following upstroke of the piston compresses the explosive mixture in the explosion chamber, forcing it out into the capsule, C, projecting from the inlet valve chest, and this capsule being heated by the burner, D, ignites the explosive mixture, the expansive power of which forces the piston downward. The ignition of the charge is retarded until the crank is on the dead center, by the introduction into the ignition tube of a charge of mixture weaker than that contained in the cylinder. The speed of the engine is controlled by a sensitive governor contained in the pulley, and arranged to intermit the admission of the combustible gas when the speed exceeds the normal. The movements of the piston, when no combustible mixture is introduced, resulting in simply compressing and recompressing the air contained by the cylinder.

By the order of operations adopted in this engine the power cylinder is emptied of most of the residual products of combustion and a purer charge of combustible mixture is used than possible with any other system. As a consequence, the fuel, whether it be coal gas or petroleum vapor, is used to the best advantage and with the greatest economy.

The ingenious mechanism by which the necessary alternating motion of the valves is secured without the the use of gearing is worthy of notice. In engines using gears for actuating the valves, the principal and most objectionable noise is the rumble and jarring of the gearing. In this engine there is no noticeable noise; in fact, it may safely be called a noiseless engine. The inclosure of the working parts in a casing contributes largely to this result. This construction also insures a rigid base, which is an important item in a gas engine when the power is developed in the cylinder almost instantaneously. Besides this advantage, the chambered base secures in a very simple way the perfect lubrication of all the working parts, at the same time confining the oil so that it is economized to the fullest extent without being scattered about where it is not wanted.

The motor is lubricated by a single oil cup, G, connected with the lower part of the cylinder. The oil received in this manner falls toward the bottom of the casing, and is repeatedly thrown up by the revolving disks.

The explosion chamber is surrounded by a water jacket, and is kept at the proper temperature by a small quantity of water circulating through it, the water being taken from a tank and circulated by gravity in stationary engines, while in portable engines the circulation of the water is effected by means of a pulsometer worked by the exhaust.

By these simple means the necessary cooling of the cylinder is effected without any outlay for water in stationary engines, and without the consumption of any power in portable engines.

The motor is started by means of a crank handle on the main shaft, having a clutch which engages the shaft as the crank is turned in the act of starting the engine, and which automatically releases the handle as soon as the engine, after one or two turns, begins to run itself.

Where petroleum is used as fuel, the carbureter

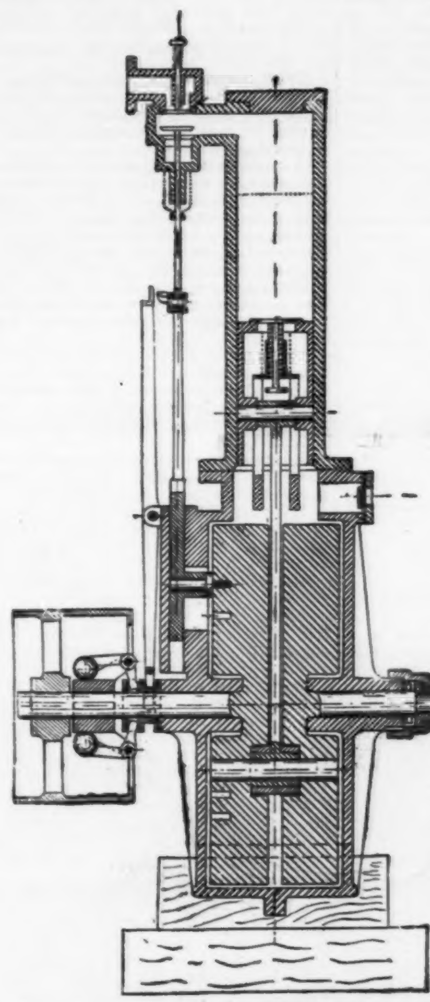


Fig. 5.- VERTICAL SECTION OF GAS MOTOR ON THE LINE OF THE SHAFT.

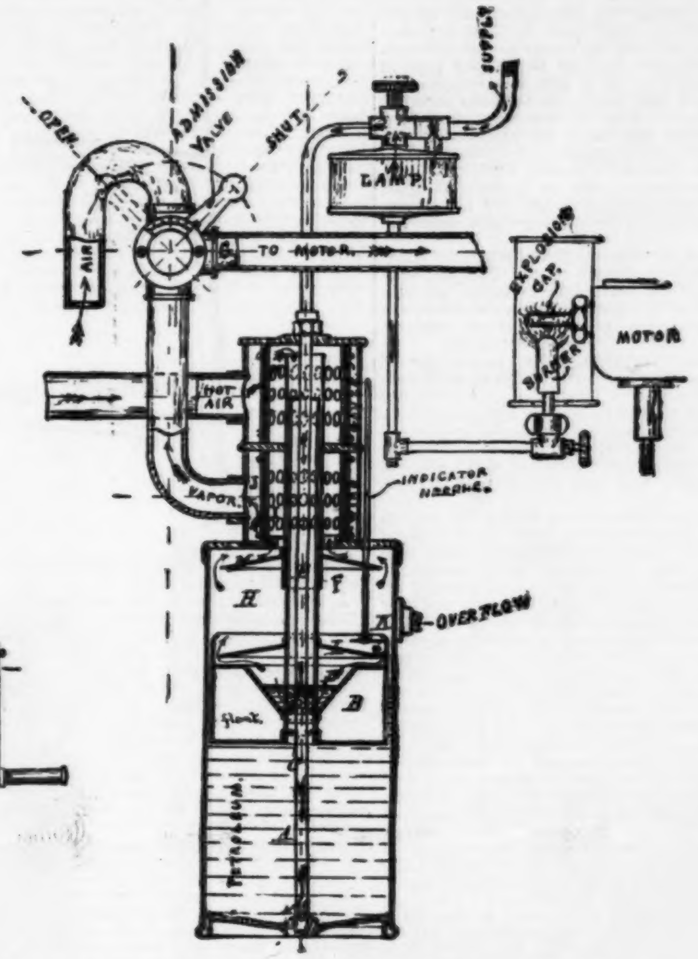


Fig. 6.—CARBURETING APPARATUS.

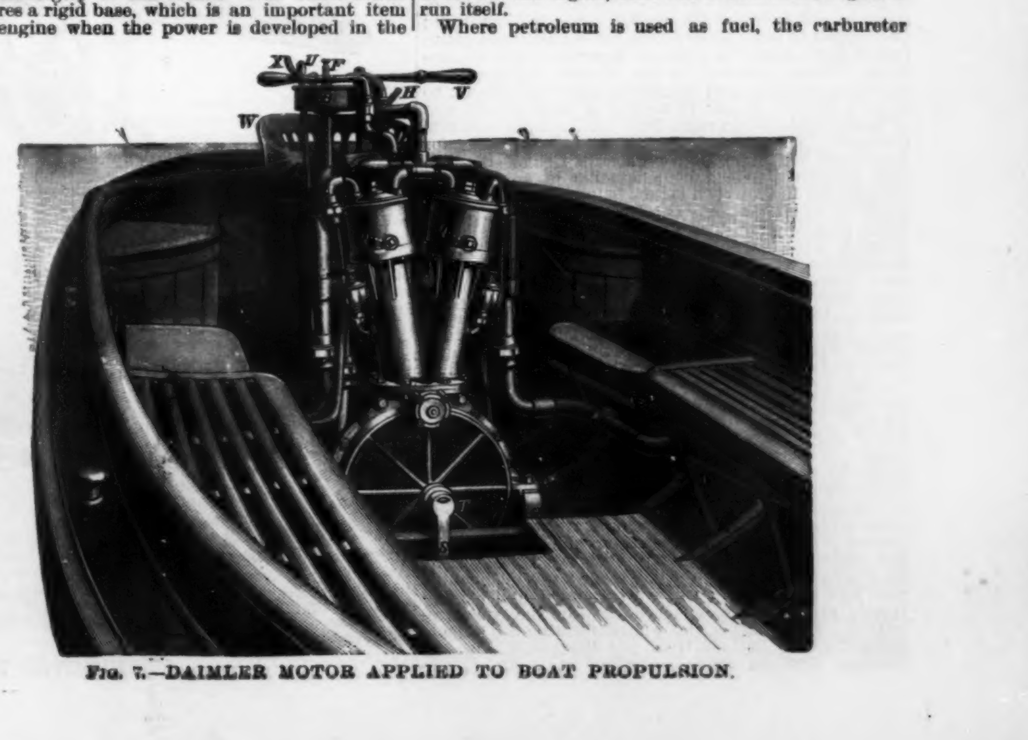


Fig. 7.—DAIMLER MOTOR APPLIED TO BOAT PROPULSION.

shown in Fig. 6 is employed. The lower part of the carbureting apparatus consists of a small petroleum tank, H, containing a float, B, which rests upon the petroleum. The float is provided with a central funnel which communicates with the main body of the liquid in the tank through a small opening at the bottom, so that while the liquid is maintained at a constant level in the funnel, it is practically isolated from the main body of the petroleum. The float is provided with an air tube entering the funnel, and perforated below the surface of the petroleum. This air tube slides freely in a tube, F, attached to the cover of the apparatus and acting as a guide, allowing the float to rise and fall, according to the supply of petroleum. Hot air is admitted to the carbureter through the pipe attached to the upper part of the apparatus, the air being heated in its passage to the carbureter by the products of combustion, which pass through a jacket surrounding the air pipe, on their way to the open air. The carbureted air passes through the vapor pipe in the direction indicated by the arrow, and unites with a stream of air drawn into the motor cylinder through the admission valve, G. This valve is provided with a graduated scale, which facilitates the adjustment. It has also an automatically operating safety valve. The reservoir, H, is filled through a supply pipe extending down to the bottom through the air tubes and float. The supply pipe communicates with the lamp font, which furnishes the fuel to the burner which heats the ignition capsule.

The time required for heating the capsule and starting the motor is only a minute or so. The motor is stopped temporarily by shutting off the supply of combustible gas, allowing the ignition burner to continue burning, but for a complete stop the ignition burner is extinguished in addition to shutting off the gas.

This motor is not only admirably adapted for all stationary purposes, but has been applied very successfully to the propulsion of small boats, to operating street cars and trolleys and to road wagons and carriages. The smallest tramway in the world is operated in the streets of Cannstadt, Germany. The car is driven by a one horse power motor of this class. It will carry ten persons and will run a mile in four minutes.

Boats driven by these motors are, during the season, in daily operation on Bowery Bay, north shore of Long Island City. Boats of the same class are running successfully on many of the lakes and rivers in Europe.

As this motor is readily supplied with fuel and is independent of water supply, it can be used in many places where a steam engine would be out of the question. It will undoubtedly be largely used for agricultural purposes, when it will find applications in thrashing, grain cleaning, wood sawing, feed cutting, churning, cider making, and in many other ways which will suggest themselves to our readers. It will also be welcomed by small manufacturers all over the country who are in need of a motor of this kind. Many of these power users have been obliged to make use of animal, or even hand or foot power. Others have used small steam engines, which are proverbially troublesome. We imagine an engine of the class described will be gladly adopted by the small manufacturers who are remote from the great centers of business.

Another application of this motor will undoubtedly be to pumping water for irrigation, for filling house tanks and for railroad water supply tanks.

It would be a difficult task to describe in detail the numerous uses to which an engine of this kind can be applied, but it is possible that for isolated electric lighting it may find greater use than in anything else to which power is applied.

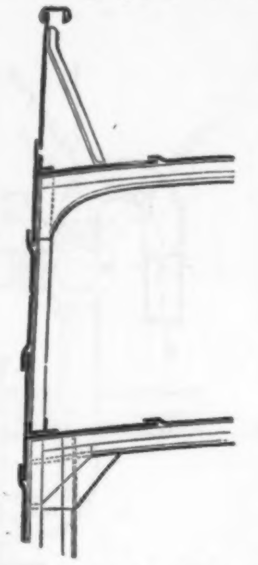
In the recent trial of road vehicles in France the carriages propelled by means of the Daimler motor took the lead and secured the prizes.

This motor is manufactured by the Daimler Motor Company, Nos. 937 to 941 Steinway Avenue, Steinway, Long Island City, N. Y., where motors from 1 to 10 horse power can be seen in actual operation. The New York office is at No. 111 East Fourteenth Street.

NEW METHOD OF FITTING SHELL AND DECK PLATING IN SHIPS.

THERE are four outstanding directions in which inventive shipbuilders have within recent years succeeded in saving material and labor in ship construction. These are—sectional framing, or framing of one entire section in place of two or more riveted combinations; plates of great length and breadth, saving butts and landings; overlapped in place of strapped butts; and cold flanging of plate edges, in place of separate angle connections. These, however, do not exhaust the means by which painstaking and ingenious shipbuilders seek to effect a further saving in weight of material and cost of labor, while at the same time maintaining requisite strength. A system of plating ships which has for some time been patented by Messrs. Bell & Rocliffe, and submitted to the consideration of shipbuilders throughout the country, is now being adopted in daily practice by Messrs. W. Doxford & Sons, of Pallion Yard, Sunderland. The raison d'etre of the system in question is the dispensing with packing or lining pieces throughout, and at the same time securing an equally neat, tight and strong job. Packing, it is well recognized, does not contribute to strength, but is merely an addition to weight, forty or fifty tons, and even more in some large ships, the absence of which is very much better than its presence; provided the structural items proper can be manipulated so as to bear closely "metal to metal." At present, the shell and deck plating, with strakes worked on the usual raised and sunk, or "in and out" principle, have packing or filling slips fitted on every frame or beam, behind the outside or raised strakes. The new system dispenses with all such fillings, the improvement being effected by joggling or kinking the edges of each outside strake of plating over the edges of the adjoining inner strakes; every strake thereby being brought right home to the frames or beams without any intervening liners. For the joggling or kinking of the plate edges, Messrs. Doxford have invented and had made a special machine tool, now in operation in their ship yard, and expeditiously and effectively accomplishing the work required. The edges of the plates forming the outside strakes, as will be seen from our illustration, are run through between rollers, working in a gap of the frame of the machine, which rollers are so shaped and adjusted relatively to each other as to form the joggle or indent required as the plate passes through.

The system has been applied partially to one of the vessels recently built by Messrs. Doxford & Sons; and to another vessel just launched the system has been applied to the plating throughout, from keel to gunwale, and from end to end, including, of course, deck and tank top. No difficulty whatever has been found in carrying the joggling right out to the ends, where, owing to the curve and twist of the strakes, difficulty might have been anticipated. This even applies to outer plates, or those under the counter, and plates above and below the propeller boss, as no



difficulty is experienced in passing plates of any set through the joggling rolls.

A few particulars of the saving said to have been effected in labor and weight of material, and of consequent gain in dead weight carrying capability obtained will be of interest to shipbuilders and shipowners alike. The vessel just finished is 2,700 tons register, the total weight of metal worked into her structure being about 1,300 tons. As compared with a similar vessel in which the joggling system had no place, there has been a saving in weight of hull of about thirty-eight tons, or a net gain in material saved of 2 per cent. Three-fourths of this total is made up of the weight of packing and liners dispensed with, and close on one-fourth of it by the weight of cement saved, owing to the outer strake of plating on the bottom being brought up close to the frames. As regards labor, the gain is also clear and considerable. The work of riveting through two-ply of material is obviously less difficult and exhausting than through three-ply, as is the case when packing is present. The work of fitting, tapering, templating, and punching the packing pieces and liners is in itself no small item, and dispensing with it means, in the case of large vessels, a saving of some consequence, especially in these days of minute economies. Falling to be deducted from the total saving in labor and material is the cost of joggling the plates by the special mechine, which, however, is only about one-tenth of the total. The gain in carrying capability is not quite equivalent to the thirty-eight tons of material saved, because from this figure must be deducted some ten tons of loss in displacement due to the finer form of the hull caused by the inward indent given to the outer or raised strakes of plating by this system. The perpetual gain, however, of some twenty-eight tons carrying power secured by this system in a vessel of 2,700 tons register over a vessel of the same size built on the ordinary principle is a consideration which ship owners will be glad to note and appreciate.

As regards the important question of structural strength, it is quite obvious the system effects it only for its betterment. The ideal in structural work of "metal-to-metal," without packings or filling of any kind is attained, and the joggling especially, as carefully carried out by the Doxford machine, being in the nature of a corrugation of the plating, adds to the rigidity of the material.—The Engineer, London.

IRONCLAD CARS.

By J. W. GREER.

EVER since street cars have been used trouble has been experienced by reason of the panels cracking. This trouble is not confined to any particular make or class of cars, but sooner or later develops to a greater or less degree in all.

It is not only an eyesore and source of annoyance to the manager who takes a pride in the appearance of his rolling stock, to see a hideous gap open up in the side or end panels of a car just received from his pet maker, or one which at considerable expense he has recently had repaneled and painted, but he also realizes that it means the entrance of water to the framework and the speedy destruction of the whole car unless checked, and the checking simply amounts in many instances to a repetition of repaneling and recracking.

The remedy which the writer invented (but made no attempt to patent) in the days when he was a journeyman, and which is being used successfully by the various roads with which he has been connected during the several stages of his evolution toward "the office," is described as follows:

Remove the mouldings, irons and water drips from the car to be repaneled, and then, instead of taking off the wooden panel, leave it just as it is.

Take No. 20 charcoal sheet iron, smooth finished, and cut with tinner's snips into sections just long enough to cover the space from center to center of adjoining pillars, and wide enough to reach from the center of the moulding on the sash rail to the center of the water drip.

Punch holes with sharp pointed punch and a hammer, at intervals of three-fourths of an inch and one-eighth from the edge. Slush the wooden panel and the inside of the iron one with a heavy coat of scraps or mineral paint mixed with japan.

Nail the iron panel down with No. 10 wire tacks. These tacks have a broad, thin, flat head, will not break or pull out, and penetrate through the wooden panel into the frame beneath.

If the work is properly done, the iron panel will be perfectly smooth and fit the wooden one airtight.

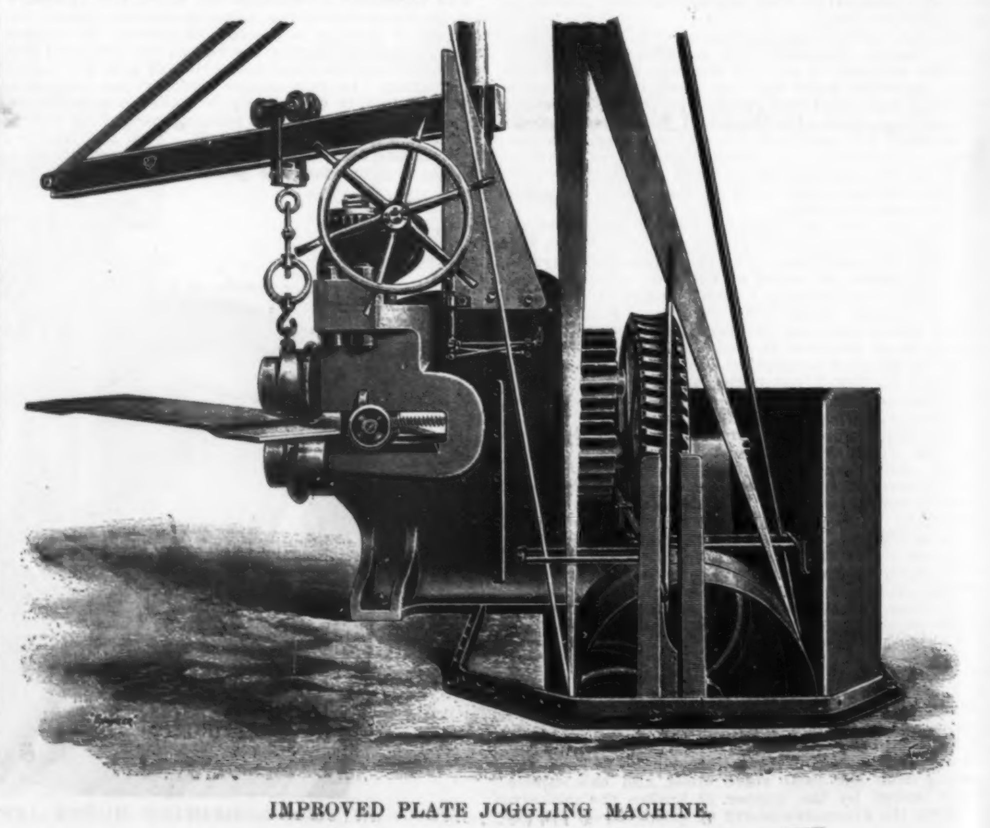
The edges of the iron panels are separated just enough to let the screws which hold the mouldings pass between them.

The water drip hides the tacks at the belt rail and the half round iron moulding covers those at the sash rail.

Some builders strap the panels at each pillar with band iron, and this may be used to hide the tacks at the vertical joints. Where the panels were not originally strapped, use seven-eighths inch beveled edge iron, one-eighth thick, drilled for No. 10 screws every two inches. Before the mouldings, irons and drip are replaced the iron panels must be thoroughly primed twice with a mixture of lamp black and white lead thinned with japan gold size.

All colors used on iron must be ground in japan (except the white lead) and should be used flat. For primers, rough stuff and putty should be mixed with japan gold size and no oil used.

Iron panels painted in this way will never scale, turtle shell, or blister; in fact, it is hard work even to burn the paint off with a torch. Before screwing on the



IMPROVED PLATE JOGGLING MACHINE.

mouldings, iron and drip, coat the side which comes against the panel with a paste of white lead and whiting mixed with japan gold size and thick enough to make a watertight joint. Screw the mouldings on with No. 10 flat head screws, countersunk even, and long enough to penetrate through the wooden panel into the frame. After the cars are painted it is impossible to tell from outward appearance an ironclad from a wooden paneled car, free from cracks.

The object of cutting the panels in sections is to overcome contraction and expansion, and also to facilitate repairs, should such ever become necessary. If, by some extraordinary accident, a hole should be knocked through one of the sheets, it is only necessary to remove the one damaged, entailing but little work or expense. The great number of tacks used is for the double purpose of preventing contraction and expansion and bracing the framework. It will be seen at a glance that it is impossible for a joint to work after a car has been sheeted with iron as described, as every piece of the main skeleton is bound together and braced by the iron panels.

Once in the lifetime of a car is all that it is necessary to sheet it with iron, and the life of a car is much prolonged by the operation. The painter should remember that the paints as mixed for the ironwork will be unfit for the woodwork, which is exposed, and prepare the mixtures separately for the different purposes.

It will be found advantageous by those who will take the trouble to try it (not only on ironclad cars, but wooden panels as well) to have all striping, gilding and ornamentation done directly on the flat color and all the varnish, both rubbing and finishing, put over it. As the varnish is put on to protect the paint, it follows that if the ornaments, striping and gilding are put on the rubbing varnish they crack and peel off before the paint itself is affected, and give a ragged aspect to a car which does not otherwise need painting. The usual practice is to put these things on the color and varnish coat, after it is rubbed, or on the first coat of rubbing varnish.

Of course, no color varnish coat is used in the method above. This digression has nothing to do with the subject, but is thrown out as a hint for money saving in the paint shop.

To returnito the subject, briefly, the advantages of ironclad cars are as follows, viz.:

The panels are cheaper and easier to put on than wood.

They do not crack, and look well as long as the frame lasts.

The repairs on car bodies are reduced to a minimum.

The life of the car is greatly lengthened.

The pay roll in the shops is wonderfully reduced.

The only disadvantage is an increase of weight equal to about 400 pounds to a sixteen foot closed car.

My reason for going so minutely into details is that those wishing to try the ironclads may at once meet with success, without the numerous experiments which led up to the method described. When the member from "Way-back" rises to inquire "What becomes of the contraction and expansion?" we will simply have to reply that it has gone the same way as that of the old-fashioned expansion joint in track construction.—Street Railway Review.

FIXING THE DISPATCH TUBES TO THE PIGEONS.

SETTING THE PIGEONS FREE AT THE STERN OF THE MANOUBIA.

RUSSIAN WATERWAYS.

Several important canal projects are at present under consideration in Russia, where the necessity of increasing the means of communication is being more and more realized. One of the most important schemes is that of connecting the White Sea with the Baltic by means of a canal, which will be about a hundred and sixty miles long. There already exists a waterway ten feet deep about half of this distance, and this only requires deepening. The Neva River forms the Lakes of Ladoga, and Onega, and Swir between the two. The canal would proceed from the Onega Lake, at the town of Pouzeny, situated at the end of the lake, then follow the Pouzeny River to the Lake of Langen, which lies at the water boundary between the Lake of Onega and the White Sea, then cut through the Lakes of Matko, Telekino, and Wyg, and finally, through the River Wyg, reach the White Sea. A recent German review says that this plan is not altogether new, but was under discussion as far back as 1870, when the minister of commerce drew attention to the vast importance a waterway of this kind would possess. A plan for a canal about thirty feet deep was also, at a later period, proceeded with, but the matter was allowed to drop. Last year the government, however, ordered it to be taken up again; some preparatory work was done, and the cost of the canal was calculated at ten million rubles, or £1,500,000. Another still older project is the bringing about of a connection between the Black Sea and the Caspian Sea. However important such a waterway would be, there is one drawback, namely, the fact that the Azov Sea, which is bound to form a link in the chain, is only navigable for vessels up to fifteen feet draught. The connection between the Black and the Caspian Seas can only be established in two different manners. According to one plan, the Volga would be used as a waterway as far as Zarizyn, from whence a canal of about fifty-three miles length would afford connection with the River Don, and, finally, the Don would form the waterway as far as the Sea of Azov. The cost is calculated at about £2,800,000. The canal would proceed from the Volga, below Zarizyn, reach the division of the watershed between the two rivers in the Valley of Prodowayo, and having passed this, cut the Valley at Kapowka. The highest point up the canal would be some two hundred feet above the level of the sea. There would have to be twenty-one locks, and vessels of 500 to 600 tons would be able to pass through in seventy hours and smaller vessels in about twenty-four hours. According to another and later plan, the Don would be utilized as far as the mouth of the River Manitsch, from whence the canal would follow this river, pass the division of the watershed between the two seas, and follow the River Kara to the Caspian Sea. A commencement in this direction has already been made by the cutting through of the Isthmus of Perskop, a distance of about ten miles, by which the Crimea is connected with the continent. The waterway from Odessa to Mariapole has thereby been reduced about one hundred and twenty-five miles, but this will not attain its full importance until the canal connects the Azov Sea with the Caspian.

SETTING PIGEONS FREE AT SEA.

After the accident that happened to the Gascogne, it was asked on all sides how news might be received from a vessel at sea. By an extraordinary chance, the Gascogne had been met by no other ship. How could such a contingency be remedied? The use of carrier pigeons, which render so many services on land, was at once thought of. But there was one question to be answered: What would be the attitude of the pigeons at sea? Would they, after the preliminary carriage to the point of embarking, withstand their imprisonment on board? Would they or would they not suffer seasickness? Finally, on being set free, would they start for their respective destinations, or, seized with fear, would they settle upon the spars? These two last points are of great importance.

It was in order to solve this complicated problem that the Petit Journal put itself at the head of a pigeon fancier movement such as has not been seen within the memory of amateurs. After setting free sixty thousand pigeons at the Trocadero, our contemporary chartered a transatlantic steamer, the Manoubia, and invited the owners of carrier pigeons to a conclusive experiment. It was a question of shipping the graceful messengers and setting them free at various distances at sea.

The embarkation was fixed for Saturday, June 29. The port selected was Saint Nazaire. On the evening before sailing, the baskets arrived in so great numbers that it was necessary to pass the night in order to proceed to the multiple operations necessitated by this extraordinary competition. Five thousand pigeons had been sent, and it was necessary to receive them, register them, sort them, classify the baskets by distances in order to prevent any subject of error later on, to countermark each pigeon's wing with the stamp of the Petit Journal, to tag the baskets and to constantly feed the birds, and especially to water then, since the pigeon cannot do without its supply of pure water. The manner in which the owners inform the receivers that their birds are thirsty is curious. Upon all the baskets there appears a placard through which the pigeons speak personally, as it were, as follows:

Something to drink, please.
We are thirsty.
Fresh water, if you please.
Please fill our trough.

This appeal is heard, and the water carriers pass about continuously, while the grain falls into the cages.

A selection having been made at the station, the cages were put aboard the cars to be taken to the wharf. Having been placed aboard the Manoubia, there was a final verification and another registering, and then adieu to terra firma. The Manoubia reached the open sea abreast of Croisic and Belle Isle, pointing toward the west.

What says the barometer? Variable. Apprentice sailors such as we would perhaps prefer much fairer weather, but the pigeon fanciers are delighted. The wind blows from the open and the sky is overcast, both conditions excellent for the pigeons, which dread the reverberation of too glowing a sun.

All the afternoon men are at work either watering the pigeons or attaching dispatches to the messengers, or else guarding the cages for fear of a squall. Mean-

while the zealous become cool, enthusiasm grows weak, and of the convinced fanciers, several lie upon the deck in careless poses.

The night passed rather inauspiciously for the fanciers, but admirably for the pigeons, not one of which was seasick.

At three o'clock there was an awakening of all by stroke of bell; every one came on deck and preparations were made for the freeing at 60 miles, which was appointed for four o'clock. The baskets were carried aft. The pigeons understood that the moment had arrived and gave evident signs of impatience. The doors were opened; what was going to happen?

The pigeons, perhaps with a little stupefaction, came out of their provisional abode. It was feared that they would not leave the upper works or yards, but they hastened to cross them with a loud noise of wings and were seen grouped in the air and turning round and round to the number of fifteen hundred. In five minutes they had disappeared.

At eight o'clock there was a second setting free under the same conditions at 120 miles. The sea being decidedly too rough for the passengers, the Manoubia put in at Belle Isle. There remain two thousand pigeons to be countermarked for the settings free at 180 and 300 miles.

The first results made known were very satisfactory. Not only did the bearers of dispatches return accurately, but the generality of the battalions gave proof of extraordinary valiantness. There were scarcely more than two or three that failed to get their bearings and remained upon the spars. As for the rest, they betook themselves toward terra firma with admirable precision. Dispatches from all parts told of the return of the birds to the cotes.—L'Illustration.

MERCUROGRAPHIC METHODS OF PHOTO-ENGRAVING.

By Thomas Bolas, F.I.C., F.C.S.

Photo-etching processes, based either upon the increased readiness with which amalgamated portions of metal plates dissolve in some acid or the greater resistance which they offer to other acids, have been known for some years, but recently Mr. Villon has classified such methods, and so far simplified some of them as to render them easily serviceable for the ordinary work of the etcher, and, moreover, the application of photography to these methods is a very easy matter. The basis of the process in its non-photographic aspect may be illustrated by a few examples. An ink is made by smoothly mixing together the following:

	Grains.
Water	100
Add and dissolve	
Sugar	50
Glycerine	50
Alcohol	100
Finally mix in	
Precipitated biniodide of mercury	40

Or a crayon can be made by incorporating

Biniodide of mercury	100
Mercurous nitrate	10
Powdered gum	20
Water, a sufficient quantity to make a stiff paste.	

With either of the above, writing or drawing is executed on a polished zinc plate, with the result that the subject shows as bright amalgamated lines on the bluish-gray surface of the zinc, and such a plate, having been varnished at the back, is etched with 3½ per cent. nitric acid, or with hydrochloric acid of similar strength. The weak nitric acid attacks the amalgamated lines and gives an engraving in intaglio, while the weak hydrochlorate attacks the ground and gives an engraving in relief, adapted for typographic printing. In either case, should the lines show signs of being underbitten, the plate should be washed, wiped dry with a soft cloth, and carefully rolled over with the following rebiting ground, care, of course, being taken to use a hard, smooth roller, and not to let the rebiting ground go into the etched cavities. A little heat will cause the rebiting ground to flow down the sides of the relief, and so protect them; after which the etching is resumed.

REBITING GROUND.

	Grains.
Vaseline	100
Beeswax	12
Linseed oil	5
Lampblack	5

When an original is to be reproduced by photography, a photo-lithographic transfer is made and put down upon stone or metal in the ordinary way, but, instead of inking the design with an ordinary lithographic printing ink, the following is used:

LITHOGRAPHIC AMALGAMATING INK.

	Parts.
Wax	40
Resin	30
Resin soap	20
Biniodide of mercury	10

A print is now taken on transfer paper and put down upon a zinc plate. In two or three hours the lines become amalgamated, the image is washed with turpentine, and the plate is etched as above. Alternatives are to use the above amalgamating ink in the preparation of the original photographic transfer, or to dust the face of the transfer with biniodide of mercury. Again, the transfer may be made to zinc or copper with an ordinary fatty ink, and the image on the plate may be dusted with the biniodide of mercury. Another method is to treat the plate as for the ordinary dusting-on process (a gum or sugar and bichromate mixture), and, after exposure, to dust with the biniodide of mercury. When the amalgamated image is on copper, several methods of printing are available, but the simplest consists in rolling up the amalgamated copper with ordinary lithographic ink, which will only take on the unamalgamated parts, but the amalgamation must be kept up by occasional damping with a weak solution of mercurous nitrate, or by carefully dabbing it over with the preparation known to the pharmaceutical chemist as "mercury with chalk."

THE PRODUCTION OF AERATED WATERS ON A SMALL SCALE.

The manufacture of aerated waters, including artificial mineral waters, has given rise to important industries in nearly all of the cities and large towns of the civilized world. But in small isolated places a do-

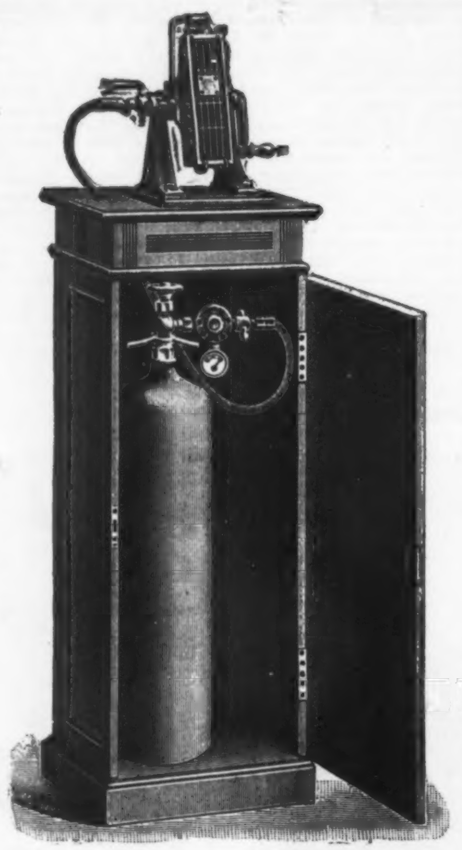


Fig. 1.—CARBONATOR OF THE LANE AND PULLMAN SYSTEM.

mestic apparatus fulfills a useful purpose. The apparatus which we illustrate, made on the Lane-Pullman system, is between the large carbonators and the portable gasogene, and with it either one or a large number of bottles may be charged, and by adding soluble salts any of the well known mineral waters may be produced. In this apparatus the carbonic acid is kept in steel tanks or cylinders, as shown in Fig. 1, which is a general view of the outfit.

Fig. 2 shows the mechanism used in filling the bottles. In the complete apparatus a stand is provided which is sufficiently large to accommodate a cylinder containing enough gas to charge 3,000 bottles. The cylinder is provided with a tight-fitting needle valve and a pressure gage to ascertain the pressure in the cylinder and to properly control the charging pressure. The bottles are placed in the metallic box shown on the top of the wooden stand. This metal box guards against accidents caused by the breakage of the bottle. This holder is secured to the stand by two trunnions. One of these trunnions is hollow and is con-

Fig. 2.—CHARGING APPARATUS FOR ONE BOTTLE.

nected with the cylinder of gas by means of a flexible rubber tube. The other trunnion is provided with a handle for shaking the bottle while it is being charged. From the trunnion to the top of the apparatus the gas is conducted by another rubber tube provided with a metallic envelope. A valve, A, controls the flow of gas to the bottle. The milled head, g, Fig. 2, is connected with a screw cap which is forced into the neck of the bottle.

In operation the apparatus is very simple. The bottle is filled with water or water containing salts or flavors and placed in the metal box and the top screwed down. The gas is then admitted to the bottle until the pressure gage shows that the desired pressure has been reached. The box, d, is then oscillated so as to be sure that the water is evenly aerated. The top, g, is then unscrewed and the bottle is put in communication with the air. The interior pressure closes instantly the small ball in the bottle which acts as a cork and the bottle is replaced by another.

The apparatus can be arranged to fill several bottles at once, as shown in Fig. 3, which represents one of the fillers. In general the same arrangement is used, but in place of the flexible tube a metal tube is used and the head, g, is modified to permit of the bottles being

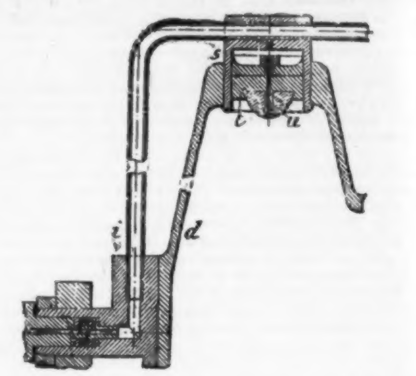


Fig. 3.—CHARGING APPARATUS FOR MORE THAN ONE BOTTLE.

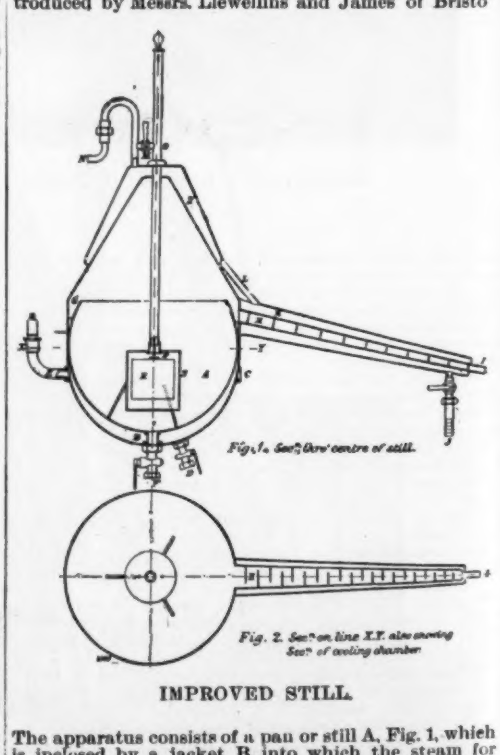
charged without so much hand work. A rubber cork of caoutchouc insures a tight fit during the charging process. T is really a movable piston, and when the pressure of the gas is removed, readily allows the bottle

Fig. 4.—APPARATUS FOR COOLING BEVERAGES.

to be removed. It is estimated that the total cost of charging bottles with this apparatus is only about one cent a dozen bottles. The same cylinder may be used to obtain iced drinks by means of the serpentine shown in Fig. 4, which is placed directly in the beverage. The ice thus obtained by the action of the gas is pure and of the same flavor as the beverage. This device has proved particularly valuable in tropical countries. For our engravings and the foregoing particulars we are indebted to the Revue Industrielle.

IMPROVED STILL.

We illustrate a useful type of still now being introduced by Messrs. Llewellins and James of Bristo



IMPROVED STILL.

The apparatus consists of a pan or still A, Fig. 1, which is inclosed by a jacket B, into which the steam for evaporating the contents of the still is admitted. The top of the still is closed by a cone as shown, there being a channel G left between it and the top of the

pan. Any liquid condensing in this cone trickles down into this channel instead of falling back into the pan, whence it would have to be evaporated. This channel, it will be seen, is in communication with an inclined delivery pipe H, fitted with baffle plates, as shown in Fig. 2. These baffle plates retard the flow, and give time for the heat to be abstracted by the water circulating in the jacket K. This jacket is divided into two parts connected by the pipe L, one part surrounding the delivery pipe and the other the top of the cone above the still. An outlet regulated by a suitable tap is provided at N. The still is provided with an automatic feeding device, by which the liquor evaporated is replaced without necessitating the interference of a workman. It consists of a down pipe O, supported on a cage S. Inside this cage is a float R, on the top of which is a valve P, which, as the float rises, closes the outlet from the down pipe. When the still is full, this pipe is closed by the upward pressure of the float, but as evaporation proceeds the float sinks, letting in a fresh supply of liquor. An outlet for draining the pan is provided at B, and there is also a hand hole in the cone. The steam jacket is fitted with a safety valve at E, and a drain pipe at D by means of which it can be cleared when necessary. The apparatus is claimed to be very efficient in working, the output for a given size of pan being far greater than from stills of the usual construction. When steam heating is not to be used, the steam jacket B is, of course, omitted.—Engineering.

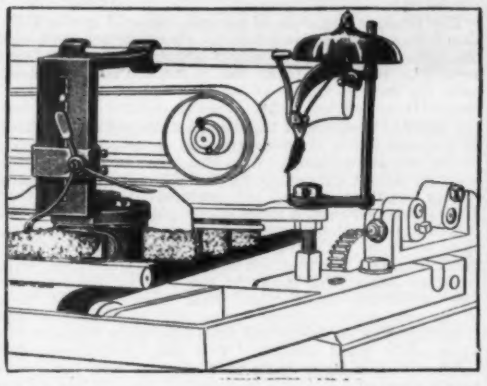
ALARM FOR APPERLY FEEDS.

WE illustrate a device which will commend itself strongly to every manufacturer employing the well known and popular Apperly feed. It is intended to prevent trouble, vexation and loss by warning the operative when the drawing breaks, as sometimes it will, under the most careful management.

When this attachment is in place there is a sentinel on guard to give instant warning of the occurrence referred to. The alarm or bell rings when the drawing breaks on the Apperly feed and will continue to ring every time the traveler crosses the feed table until the drawing is in place again.

The machine is very simple, cannot get out of order and is easily attached.

While it is true that in some mills the drawing rarely breaks, belts often break or fly off, and the cost of these alarms is so reasonable that few manufacturers can afford to be without them. It is well known by carders that when the drawing breaks on a finisher card and the machine does not receive instant attention, it is necessary to run the feed out and usually put in new spools. This means a large amount of waste and loss of time. The sentinel alarm is designed to prevent this by calling instant attention to the broken drawing. The bell will not ring unless the drawing is broken, and it indicates by the number of strokes the folds of drawing missing, which can be safely added



BALCOM'S SENTINEL ALARM FOR APPERLY FEEDS.

without detriment to the quality of the work. George S. Harwood & Son, agents, 7 Water Street, Boston.—Textile Record.

MANUFACTURE OF WHITE PINE BARRELS.

TIGHT white pine kegs and barrels are used principally for storing pork, pickles, sirups, fish, tripe, lard, chemicals, etc. The staves and heads are made from the white pine trees growing in the southern part of New Hampshire and are shipped to the barrel manufacturer already cut into proper shape and beveled so that when drawn together by the operator the joints fit perfectly. The barrels, when finished, range from about 10 inches in height and about 11 inches in diameter up to 30 inches in height and 20 inches in diameter. The portion of the tree used for staves is between each set of limbs, these parts of the tree being free of knots. The hoop strips with which the barrels are bound are taken from young elm, white birch, black ash, and maple saplings. They come principally from Maine and New York State, the farmers cutting the saplings late in the fall and winter as soon as the leaves are off and the sap stops running. Each sapling will make from two to five strips, each being from 3 to 6½ feet in length, about 1 inch in width and about ⅜ to ½ of an inch in thickness at the center.

After cutting, they are seasoned and tied up into bundles containing 100 strips each, and shipped to the cooperage, where they are soaked in tanks of cold water to make them pliable. About 2,000 of these dry strips are placed at a time in these tanks and left to soak from two to five days. Black ash strips are the best for binding barrels to be used for wet material, the hoops not rotting as quickly as the others on account of their growing in wet and marshy places. The first process in barrel making is the setting or trussing up of the staves. This operation is performed by placing one end of the staves inside of what is called a truss hoop. These hoops are made of wrought iron and are about ¾ of an inch in width and about ⅛ an inch in thickness, and range from about 7 to 17½ inches in diameter. Each size barrel takes a certain number of staves, two sizes or widths being used for each. After placing the wide and narrow staves alternately in position in the truss hoop, which is placed flare side up, the operator loops a rope around the upper ends and by means of a windlass draws them together tightly. Another hoop is then placed over the ends and the trussed staves are ready to be heated. The heating process is performed by placing the material over a small circular cast iron stove and allowing them to heat gradually through for about three minutes. These stoves or heaters are from 18 to 30 inches in height and from 8 to 12 inches in diameter, wood being used for heating. Each set of trussed staves is placed over a certain sized stove, with a space between the two large enough to prevent the material from burning.

The object of heating is to take the brittleness out of the material. If the staves were struck with the hammer when cold, they would break instantly and become useless. The heating process causes the staves to slightly shrink and bulge out from each other, making it necessary for them to be retrussed. This is performed in about the same manner as before with the rope, then hammered into place and the truss hoops forced further down, making the barrel staves secure again for the next operation. It is then placed into what is called a squaw or jack and the

MANUFACTURE OF TIGHT WHITE PINE BARRELS.

process of chamfering, howeling and crozing performed. A jack hoop is first forced tightly around the jack, which is drawn up against the barrel, holding it securely in place, the operator then chamfering or beveling the edge with a broad knife or chamfer to the depth of about three-fourths of an inch. The top of the barrel is then evened off, howeled and crozed. Connected to the underside of the crozing instrument is a howeler which the operator passes around on the interior side of the barrel just below the beveled edge, cutting out a slight circular groove about 1 inch in width. The instrument is then turned upside down and the croze passed around in the same manner. The instrument contains three steel knives which are placed in such a position that when operated they cut out a ⋖ shaped groove about one-eighth of an inch in depth. The center of the barrel on the outside is then smoothed off with a spokeshave and hooped. The hoop strips, if too stiff, are first passed through a hoop roller, the passage between the 10 inch elm wood roller and the rubber belt of the apparatus making the material pliable, so that the hoop can be bent and formed without breaking. A notch is first cut into the strip about 8 inches from the end and the strip passed tightly around the barrel to find the proper place for the second notch, the operator using his thumb as a guide. The notches are cut about half way through the width of the strip at one end and are about 4 inches in length. After being trimmed properly it is locked and put over the barrel with the ends turned in under, it being chalked first to prevent the hoops from slipping.

Each hoop is forced in place by means of a hammer and driver. After two or three hoops are put in position the head is placed into the croze, after which the rest of the hoops are forced into place. It requires an experienced man to put on the last or chime hoop, it being very easily broken in forcing it over the top of the barrel. This hoop is forced and hammered down in place by a circular iron instrument called a maul.

The projecting ends of the hoops are then chopped off with an adz. If any part of the barrel springs open, the crevices are filled up with fresh water flags, which swells up when it comes in contact with the liquid inside, making the barrel tight, so that none of the contents can escape.

The sketches were taken from the plant of Proctor Brothers & Company, Jersey City, N. J., who turn out with fifteen hands about 2,250 barrels weekly.

THE DISPOSITION OF THE LOUISIANA MOLASSES CROP.*

By Dr. W. C. STUBBS.

THIS question confronts every sugar planter in Louisiana with striking significance. Molasses of high food value is daily being thrown into swamps, bayous and rivers, because there is not a sufficient demand for it to justify the expenditure of cooperage and freight to market. This, too, when millions of our fellow citizens are living upon higher priced and less nutritious foods.

In my travels through this and other States, I am constantly reminded of the possibility of establishing a market everywhere throughout the country for the sale of molasses as an article of food, not as a delicacy, but as a component part of a wholesome ration for the support of the toiling masses, whose daily wages will not permit them to indulge in high-priced foods. This reminder comes from the manifestations of surprise on the part of the consumer, whenever told of the extremely low prices obtained for this by-product in our sugar houses. If a similar system to that practiced by the Standard Oil Company for the transportation and sale of their oils could be adopted for molasses, prices would advance so as to relieve us of finding other uses for it.

Transportation in tank cars and large iron reservoirs at every city, town and village, from which barrels could be filled for the consumer, would inevitably lead to prices which would be remunerative to planters and satisfactory to consumers. For, say what we will about its adaptability to other uses, the highest value of molasses must ultimately be found in human food. In addition to its potential energy when consumed, its sweet taste makes it far more palatable than farinaceous foods. But the evolution of such a system requires time, and in the meanwhile our planters are demanding an immediate solution of the perplexing question.

"What shall we do with it?"

Molasses can be used in the arts in the following ways:

1. As a fertilizer; 2, in the manufacture of alcohol, rum and weaker spirits; 3, as an addition to cement in building; 4, as a feed stuff for man and beast; and 5, as a fuel. Each of these will be discussed in order. Before discussion I will say that two kinds of molasses were selected and carefully analyzed with reference to their adaptability to supplying each of the above uses, save as an addition to cement. In this last instance, an insufficient number of tests have been made to establish an accurate relation between the composition of molasses and its fitness for serving in a cement.

Sample No. 1 was diffusion molasses from the station sugar house.

Sample No. 2 was mill molasses from the house of J. & C. Jacobs, St. James parish, and sent for analysis.

1. MOLASSES AS A FERTILIZER.

ANALYSIS OF MOLASSES AS A FERTILIZER.

Diffusion No. 1.

Nitrogen	0·593
Phosphoric acid	0·1423
Potash	2·47
Relative commercial value per ton	$2.15
Value per gallon	0·01·3

Mill No. 2.

Nitrogen	0·224
Phosphoric acid	0·2400
Potash	2·09
Relative commercial value per ton	$1.12
Value per gallon	0·00·7

* A paper read before the Louisiana Sugar Planters' Association, July 11, 1895. From the Louisiana Planter.

The commercial value is calculated upon the following tariff of prices: Nitrogen, 15 cents; phosphoric acid, 5 cents; and potash 5 cents per pound.

Attention is called to the great difference between the contents of nitrogen and phosphoric acid in the diffusion and mill molasses. The excess of nitrogen in the diffusion juice, not removable by heat and lime, was pointed out last year in a paper by Dr. Maxwell before this association.

The smaller quantity of phosphoric acid in the diffusion juice was doubtless due to clarification with acid phosphate, by which a larger amount of phosphoric acid was removed from the juice. These molasses have theoretical values as fertilizers of $2 15 and $1.12 respectively per ton. The viscous nature of molasses, the present absence of facilities for proper distribution of it in our fields, its resistance to decomposition and its known attraction for flies and other insects, all conspire to render extremely doubtful the profit in using it as a fertilizer. I may say, however, in passing, that Mr. George Brulay, a large sugar planter on the Rio Grande, near Brownsville, has practiced its application to cane for several years, and he believes with good results. His method is to cover the canes with it, after depositing them in the row at planting before covering them with dirt. Mr. Brulay lives in an arid region where irrigation is practiced and the affinity of molasses for moisture may explain the apparently good results. The use of molasses as a fertilizer on a large scale is therefore not yet to be recommended.

2. MOLASSES FOR THE MANUFACTURE OF ALCOHOL.

In the fermentation of molasses the sucrose is first converted into glucose. Of the glucose present 95 per cent. is fermentable into alcohol, 4 per cent. into succinic acid and glycerine, and 1 per cent. is consumed by the ferment. Every 100 parts of glucose which passes into alcohol makes 51·11 per cent. of the latter. Besides it has been found in our laboratory that about 45 per cent. of the carbohydrates not sugars (mainly pentoses) are also fermentable into alcohol. With these figures we can calculate the alcoholic value of any molasses when its analysis is known. The following are the analyses of two samples experimented with:

ANALYSIS OF MOLASSES (ALCOHOLIC VALUE).

Diffusion No. 1.

Sucrose D. P.	30·58
Glucose	29·00
Total glucose after inversion	61·19
Organic solids not sugar	11·20

Mill No. 2.

Sucrose D. P.	32·60
Glucose	28·96
Total glucose after inversion	63·27
Organic solids not sugar	5·72

Ninety-five per cent. of the total glucose and about 45 per cent. of the carbohydrates not sugar are available for alcohol. We have then 95 per cent. of 61·19 per cent., equal 58·13 per cent., and 95 per cent. of 63·27 per cent., equal 60·10 per cent., and these numbers multiplied by 51·11 per cent. equal 29 71 per cent. and 30 71 per cent. plus the alcohol from fermentable pentoses, as the respective alcoholic values of the two molasses.

Assuming 12 pounds as weight of a gallon of molasses, there would be obtained from diffusion molasses reckoned only on its sucrose and glucose contents, 3·56 pounds C. P. alcohol, or about 4 pounds of 90 per cent., alcohol, or 7·23 pounds of proof rum. Proof rum weighs 7·66 pounds per gallon, therefore 1 gallon of such molasses should yield 0·94 of a gallon of it.

Similarly a gallon of the mill molasses should yield 3·685 pounds C. P. alcohol, or 7·46 pounds of proof rum, or 1 gallon of molasses giving 0·97 of a gallon of rum. To these add the alcohol from fermentation of pentoses, and it may be assumed without much error that each molasses will yield 1 gallon of proof spirit from each gallon of molasses.

The Louisiana Alcohol Company, in this city, is engaged in the extensive manufacture of alcohol from molasses, making a most excellent article. Two barrels of their product obtained some months ago have been used in various analytical processes and found very satisfactory. The price paid was 20 cents per proof gallon, without the revenue tax. The present tax on alcohol and the necessary government surveillance over every still prevents the extensive and profitable conversion of much of our molasses into alcohol. If, with this industry, as with others, the claim is made of doubling the value of the raw product by manufacture, the value of a gallon of molasses should be from 7½ to 10 cents per gallon. The statistics of the United States show that three quarts of proof alcohol are made from every gallon of molasses used in this country, while only seventeen quarts are made from a bushel of corn. Therefore a gallon of molasses should be worth three-seventeenths of a bushel of corn, which, at present prices of corn, would be 8 to 10 cents per gallon.

3. ADDITION TO CEMENT IN BUILDINGS, ETC.

On a limited scale molasses has been successfully used as an addition to cements and mortars, and our technical journals occasionally advise its more extended use. However, the amount now so used, or likely to be used in the near future, is so small that no help can come to us from this source.

4. FOODSTUFF.

I have already alluded to this use as the one which will probably give a higher value to our molasses than any other. To comprehend the function which molasses performs in the animal system, it will be necessary to explain how food is used in the body. All foods consist of the following nutrients, viz.: Protein or nitrogenous matter, fats, carbohydrates and mineral matter or ash.

Under the head of protein is included all of the nitrogenous compounds known to the chemist as albuminoids, gelatinoids, amides, kreatine and other extractives. These serve to form tissue, muscle, tendon, bone, blood and brain; they also form fat and serve as fuel.

Fats form fatty tissue and also serve as fuel.

Carbohydrates can be transformed into fats, but their chief office is to furnish fuel. The minerals serve to form the bones and framework in which the fats, etc., are deposited, besides being essential to the healthy flow of the animal fluids.

Food therefore supplies the wants of the body in the following ways: (1) It forms the tissues and fluids of the body; (2) it repairs the constant wastes of the system; (3) it is stored up in the body for future use; (4) it is consumed as fuel, its potential energy being transformed either into heat or the various energies required by the body; (5) it protects, by its own consumption, tissues already formed, or more valuable ingredients fed simultaneously.

Every motion of the body, every pulsation of the heart, every exercise of thought, every emotion of the soul is attended by a consumption of material, which must be supplied in the food, or else waste of the system must occur, with death ultimately if continued too long. The animal body, like a machine, requires fuel to run it. Unlike the machine, however, it cannot stop for repairs, and therefore must take in with the fuel the materials needed for repair or for growth. In the machine we use coal and wood for fuel, and brass and iron for repairs and enlargement. To make repairs or additions to a machine we stop it. In the animal body food is used for both fuel, repairs and growth, and all must proceed simultaneously. To stop the animal machine is death.

In running both the animal and the machine the energy stored up in the fuel is transformed into heat and work. The potential energy of the coal is partly transformed into mechanical power, which the engine uses for work, and partly into heat, which the engine does not use and which is wasted. The potential energy of the food is transformed in the body into heat, which warms the body, and mechanical power, which performs muscular work. Besides, a part of the food also repairs and builds up the body. Again, the body can call on its own substance for fuel, and the surplus flesh and fat of to-day can be used to-morrow in running the body.

It may, therefore, be asserted that the chief uses of food are twofold: (1) To form the material of the body and repair wastes; (2) to yield heat to keep up the temperature of the body, and to produce muscular and other power for the work it has to do.

Building and repair, heat and power, are the results of taking food.

Heat and muscular power are, like light, electricity and mechanical power, forms of energy. The energy which is latent in the food becomes active on consumption, hence the value of food for fuel (like coal and wood) is expressed in terms of potential energy. The quantities in food materials, as well as in fuel proper, are determined by an instrument called the calorimeter. The one now generally used is a steel bomb, lined with platinum, within which the substance is burned. The bomb filled with oxygen gas is immersed in water contained in a metal cylinder. The material placed in a cup within the bomb is fired by passage of an electric current. The heat developed by the combustion is measured by the rise in temperature of the surrounding water, due regard being made for the absorption of heat by the metal of the bomb and for that introduced by the electric current. By means of such calorimeters the fuel value of every kind of food has been determined. It is to be regretted that different units are used by different investigators. The amount of heat necessary to raise a given weight (gramme or kilogramme in France and pound in England) of water through one degree of temperature (Centigrade in France, Fahrenheit in England) is taken as a unit and called in France a calorie (written with a small c when grammes are used and with a capital when kilos.) The English unit is called the British thermal unit and is usually written B. T. U. Instead of a unit of heat we can use a unit of mechanical energy, viz., foot pound or foot ton, which is a force that will lift one pound or ton one foot.

One calorie equals about 3·97 B. T. U, and corresponds to very nearly 1·53 foot tons.

From a large number of experiments it has been found that 1 gramme of protein has a fuel value of 4·1, 1 gramme of fats 9·3, and 1 gramme of carbohydrates 4·1 Calories. This means that 1 gramme of carbohydrates (sugar or starch) will generate enough to warm 4·1 kilogrammes of water 1° C. or 4° F., or transformed into mechanical energy will perform work such as to raise 1 ton 6·3 feet, or 6·3 tons 1 foot.

Animals are fed for maintenance, for growth, for fattening, for milk, for work, etc. It is therefore evident that the amounts of the different nutrients in the food must vary with the purpose for which they are fed. The ratio between the protein and the fats and carbohydrates is called the nutritive ratio, and must widen or narrow according to the requirements of the animal. It is well known that a laboring man requires a different diet both in quantity and quality from the gentleman of leisure. Compounding the food so as to suit the requirements of our various animals without waste and with a due regard to the cost of each ingredient of the food has been the work of many experiment stations. In this way rations, suitable for all conditions of an animal, have been given to the public, and to-day every farmer can intelligently feed his animals to meet his demands. The following are the analyses of our molasses from a feeding standpoint:

ANALYSES OF MOLASSES (FEEDING VALUE).

Diffusion No. 1.

Protein	3·71
Fat	Trace.
Carbohydrates	67·07
Water	22·35
Ash	6·87
Fiber	None.
Nutritive ratio	1 to 18
Fuel value, 1 pound	1345 C.

Mill No. 2.

Protein	1·40
Fat	Trace.
Carbohydrates	65·88
Water	26 62
Ash	6·10
Fiber	None.
Nutritive ratio	1 to 47
Fuel value, 1 pound	1307 C.

Carbohydrates is then the chief nutrient in molasses, and, as has been shown, furnishes mainly heat and muscular energy. Molasses, therefore, seems specially fitted for animals performing heavy work. Mixed with concentrated foods, rich in protein and fat, to form the material of the body and repair its wastes, this feed stuff will yield the heat and muscular energy, and the combination can form theoretically the complete ration required by our text books on "feeding." An animal of 1,000 pounds live weight at heavy work requires daily 25·5 pounds of dry matter, 2·8 pounds of protein, 13·40 pounds of carbohydrates, and 0·80 pound of fat. By using 8 pounds of cotton seed meal with 20 pounds of molasses, this requirement is very nearly reached, as the following table will show:

	Dry Matter.	Protein.	Carbohydrates.	Fat.
Eight pounds cotton seed meal	7·34	2·69	1·84	0·76
Twenty pounds molasses	16·00	0 40	13·30	—
Total	23·34	3·09	15·24	0 76
Amount required	25·50	2·80	13·40	0·80
Difference	2·16	0·29	1·84	0·04

Such a ration has never been tried and its practical use is yet doubtful, but encouraged by the universal use of cotton seed hulls (once thought only fit for fuel) as a cattle feed when properly mixed with cotton seed meal, the above is deemed worthy of suggestion and perhaps careful experiment.

The above applies to animals. With man the scientists have already been engaged in determining feeding standards suitable for his work. The dietaries of this and the older countries have been carefully examined, and numerous experiments with the respiration calorimeter have been made upon healthy specimens of the genus homo.

In Germany, Voit has published the following standards: for a laboring man at moderate work, 118 grammes of protein and 3·055 Calories of energy. For severe work, 145 grammes of protein and 4,500 calories of energy.

In this country, Dr. Atwater, after much patient investigation, has adopted the following:

	Protein	fuel.	Nutritive ratio.
Woman, with light muscular exercise	90 g.	2,400 Calories.	1-5·5
Woman, with moderate exercise	100 g.	2,700 "	1-5·6
Man, without muscular work	100 g.	2,700 "	1-5·6
Man, with light muscular work	112 g.	3,000 "	1-5 5
Man, with moderate muscular work	125 g.	3,500 "	1-5·8
Man, with hard muscular work	150 g.	4,500 "	1-6·3

With this table and another with the analyses of the articles of food, a ration can be compounded suitable for all conditions of life. Since the chief function of molasses is to furnish fuel, one pound yielding about 1,300 Calories, it is evident that the laboring man can use it to advantage in his daily ration. Besides, experiments made by Dr. Vaughan Harney show that sugars not only prolonged the time before fatigue occurred, but increased the muscular work performed from 6 to 76 per cent., according to amount sugar consumed.

Dr. S. W. Johnson, of Connecticut Experiment Station, several years ago published the following schedule of prices of nutrients in feedstuffs. This schedule gives to protein 1·6 cents per pound, to fats 4·2 cents per pound, and to carbohydrates 0·96 cent per pound.

These figures are now probably too high, but they will do to compare molasses with the standard feedstuffs offered on our market. By this tariff the following values are obtained:

1 ton diffusion molasses, $14.05; 1 gal., 8·4 cents; 1 lb., 0·7 cent.

1 ton mill molasses, $13.08; 1 gal., 7·8 cents; 1 lb., 0·65 cent.

1 ton corn meal, $19.59; 1 lb., 0·97 cent.

1 ton wheat bran, $20.22; 1 lb., 1·01 cents.

1 ton cotton seed meal, $30.37; 1 lb., 1·51 cents.

1 ton rice bran, $20.81; 1 lb., 1·04 cents.

1 ton rice polish, $21.55; 1 lb., 1·07 cents.

The prices current in the markets of this city to-day for these articles are per ton: Rice bran, $12; rice polish, $16.50; wheat bran, $17.50; corn meal, $20; and cotton seed meal, $17.50. Corn and wheat bran are imported products, and their values include transportation charges, but rice bran and polish and cotton seed meal are, like our molasses, home products, and have what may be styled initial values. Compared with these, the value of the molasses would be $8.40, $11.55 and $8.17 per ton, or 5 to 7 cents per gallon.

5. FUEL VALUE OF MOLASSES.

Much that has been said under the value of molasses as a food is applicable under this head.

The value of both foods and fuel is to-day submitted to the calorimeter for decision. The old rule given in most of our chemical physics of calculating the fuel value of any carbohydrate was, 1. "The total heat of combustion of any compound of hydrogen and carbon is the sum of the quantities of heat which the hydrogen and carbon contained in it would produce separately by their combustion," and, 2. "When hydrogen and oxygen exist in a compound in the proper proportion to form water, these constituents have no effect on the total heat of combustion." These rules have been subordinated by the direct tests of the calorimeter, and how they agree will be shown by a comparison of results given below:

Dr. Rubner, after years of experimenting, has adopted the following values of potential energy in different substances, which Dr. Atwater, of this country, has adopted after careful verification by comparisons of several thousand calculated results and actual calorimetric tests made by him:

In one gramme of protein there are 4·1 calories.
In one gramme of carbohydrates.. 4·1 "
In one gramme of fats... .... 9·3 "

To get actual calorimetric tests made by one skilled in such operations, the following samples of molasses were submitted to Dr. W. O. Atwater, who kindly performed the work without charge:

SAMPLES OF MOLASSES (FUEL VALUE).

Diffusion No. 1.

Total solids by evaporation	77·65
Sucrose D. P.	30·58
Glucose	29·00
Albuminoids	3·70
Other organic solids	7·48
Ash	6·89

Mill No. 2.

Total solids by evaporation	73·38
Sucrose D. P.	32·60
Glucose	28·96
Albuminoids	1·40
Other organic solids	4·32
Ash	6·10

The following are his results:

One gramme No. 1, on water content as received, 2,958 small calories or 2·958 large Calories.

One pound No. 1, on water content as received, 1,345 large Calories.

One pound No. 2, on water content as received, 2,876 small calories or 2·876 large Calories.

One pound No. 2, on water content as received, 1,307 large Calories.

Calculated by above values of Dr. Rubner—No. 1 has a fuel value, 1 gramme, 2,902 small calories.

No. 1 has a fuel value, 1 pound, 1,319 large Calories.

No. 2 has a fuel value, 1 gramme, 2,816 small calories.

No. 2 has a fuel value, 1 pound, 1,280 large Calories.

Based upon chemical formula, assuming the "other organic solid" as pentoses and reckoning the albuminoids as of equal value with the glucose, No. 1, with a percentage composition of 28·94 per cent. of carbon and with 22·55 per cent. of water to evaporate, will show the following:

	Calories.
28·94 per cent. x 8,080 C	2·33835
Less 22·65 per cent. x 720 C	0·16092
1 gramme dif. molasses	2·17743

	Calories.
Or 1 pound dif. molasses	979·000
Similarly 1 gramme mill molasses	2·037
And 1 pound mill molasses	926·000

In a recent report Prof. Carpenter, of Cornell University, has given the analyses and calorimetric tests of a large number of the coals of this country.

Five varieties of Pennsylvania bituminous coals, identical with those used by our sugar planters, are given. The following is the average of these analyses and tests:

AVERAGE ANALYSES OF PENNSYLVANIA BITUMINOUS COALS.

Moisture	1·68
Volatile matter	28·43
Fixed carbon	64·05
Ash	5·83
Calorimetric test value B. T. U.	14·20

One pound of this coal has a fuel value of 14,200 B. T. U. or 3,577 Calories. Comparing our molasses with this coal, we have:

DIFFUSION MOLASSES NO. 1.

By calorimetric test made by Dr. Atwater, 1 lb. = $\frac{1345}{3577}$ of 1 lb. coal.

By calculation, Dr. Rubner's methods, 1 lb. = $\frac{1319}{3577}$ of 1 lb. coal.

By calculation, using molecular weight, 1 lb. = $\frac{979}{3577}$ of 1 lb. coal.

MILL MOLASSES.

By calorimetric test made by Dr. Atwater, 1 lb. = $\frac{1307}{3577}$ of 1 lb. coal.

By calculation, Dr. Rubner's methods, 1 lb. = $\frac{1280}{3577}$ of 1 lb. coal.

By calculation, using molecular weight, 1 lb. = $\frac{926}{3577}$ of 1 lb. coal.

Disregarding all but the calorimetric tests (the others are given for comparison only) we have 1 pound diffusion molasses equals in fuel value 0·376 pound of coal; 1 pound mill molasses equals in fuel value 0·365 pound of coal. Therefore 1 ton of 2,000 pounds of coal equals 5,320 pounds of diffusion molasses and 5,480 pounds of mill molasses.

Former comparisons of fuel value of molasses have been with coal costing $4 and $5 per ton. The writer had delivered at the sugar house a few days ago 1,000 barrels of coal at a cost of $3.50 per ton. This figure then is the proper one for present comparison.

At this price one gallon of diffusion molasses is worth 0·79 cent and mill molasses 0·76 cent for fuel. These are very low values. At the last meeting of this association the writer gave as the value of a gallon of molasses for fuel, based upon the published calorimetric test of Dr. Atwater, and the price of $4 per ton for coal, 0·88 cent. Changing the value of coal to $3.50 per ton, the value becomes 0·77 cent.

Here, then, we have most concurrent results of three calorimetric tests made upon distinct samples of molasses, giving us as the fuel value of molasses 0·76 to 0·79 cent per gallon, and these values may be regarded as conclusive.

Prof. Crawley, basing his calculations upon molecular weights, gave several years ago a value of 0·65 cent per gallon. Other estimates have been too high.

In conclusion, it may be remarked that present urgent necessities may force us to burn our molasses in our furnaces, but it is a waste which economy and science condemn.

The proper disposition is to use as a feed stuff and for the manufacture of alcohol, and every energy should be expended by our planters in securing such uses as early as possible for our entire product.

COLOR PHOTOGRAPHY.

AN important paper on the theory of color photography is contributed to No. 6 of Wiedemann's Annalen by Herr Otto Wiener. The paper deals with the methods of attacking this problem which are based not upon the photography of the different constituents of colored light and their subsequent recognition—like Mr. Ives' heliochromy and similar processes—but upon the direct production of color by the influence of light upon certain chemical substances. The most recent, and in a way the most successful of these methods, is that due to Lippmann and the question raised by Herr Wiener is whether the old processes invented by Becquerel, Seebeck, and Poitevin are based upon interference colors like Lippmann's, or upon "body colors," i. e., colors produced by partial absorption of the incident light. That Lippmann's colors are due to interference may be very simply proved by breathing upon a plate with a photograph of the spectrum, when the colors quickly wander toward the violet end, this result being due to an increase in the distance between the nodal layers. This experiment cannot be applied to a spectrum photographed by Becquerel's method. But Herr Wiener succeeded, by a simple and ingenious contrivance, altering the path of the rays through the colored film by placing a rectangular prism on the plate, with its hypothenuse surface in contact with the spectrum. This experiment had the startling result that part of the spectrum covered by the prism appeared strongly displaced toward the red. Hence Zenker's theory of Becquerel's process, enunciated in 1868, which ascribed the colors to interference, is substantiated. Instead of Becquerel's homogeneous sheet of silver chloride containing subchloride, Seebeck used the powder, and Poitevin mounted the salt on paper. In these two processes the effect described is not observed. Hence these colors are body colors in these two cases. The production of these body colors is a very mysterious process, but the author hopes that here will eventually be found a satisfactory solution of the problem. To account for the production of these colors he advances a remarkable theory, which has a well-known analogy in comparative physiology. Given a collection of compounds of silver chloride and subchloride of indefinite proportions, such as those which Mr. Carey Lea calls by the collective name of "photochloride," we must suppose according to the modern kinetic theories that they are undergoing a rapid series of successive modifications. When the red combination happens to be exposed to red light, it reflects it without absorption, and will therefore no longer be affected or changed by it. Similarly for the other cases. This is another process of "adaptation." The author describes some experiments which prove that this is the true explanation, and points out the importance of this view, not only for color photography, but for the production of colors in the animal world.—Nature.

THE PLACE OF ARGON AMONG THE ELEMENTS.

THE position of argon in a classification of the elements depending on atomic weights has been recently defined by C. J. Reed (Journal of the Franklin Institute, July). The elements are assigned positions on a plane determined by abscissæ proportional to their atomic weights and ordinates proportional to their valency. Oxygen is assumed to have an electro negative valency 2, and the valency of other elements is referred to this as standard; electro-positive valency is measured upward, electro-negative downward from the zero axis. Under these conditions most of the elements fall on a peculiar series of double, equidistant, parallel straight lines, connecting elements in order of their atomic weights and separated alternately by distances corresponding to one and sixteen units of atomic weight respectively.

If the plane be now folded into a cylinder with axis parallel to the abscissæ and a circumference of eight units of valency, it is found the upper and lower parts of the connecting lines coincide; the whole of these lines then form a parallel pair of spirals on the surface of the cylinder, and valency in angular measure becomes directly proportional to atomic weight.

The regularity with which the elements of lower atomic weight fall alternately on each of the parallel spirals is very striking, but this regularity is not maintained among elements of high atomic weight, notable deviations occurring with most of the elements of which the atomic weight ranges from 100 to 130. The axis of atomic weights represents the valency + 0 or + 8 and is cut by the double spiral in fifteen points. There should then be a group of fifteen elements having a valency of zero or eight, and their atomic weights should be respectively 4, 20, 36, 52, 68, 84, 100, 116, 132, 148, 164, 180, 196, 212 and 228. All the known elements appear to be grouped together on certain regions of the surface of the cylinder, other parts remaining comparatively bare. The only members of this family to be expected to occur in terrestrial matter will be those in the inhabited regions of the cylinder surface. The hypothetical elements having atomic weights 20, 36, 84 and 132 are the most necessary from this point of view.

It seems reasonable to suppose from the peculiar position of these elements on the border line between electro-negative and electro-positive valencies, that they should be more strongly electro-negative than the corresponding members of the sulphur group, and should, nevertheless, be without valency (or octads). They should, in general, be more volatile than the corresponding members of the sulphur group. As electro-negative valency diminishes in any group with increase of atomic weight, the element 196, if it exists, cannot be expected to be electro-negative. This element should be a volatile metal, heavier and scarcer than gold, and capable of easier reduction to the metallic state; it should be capable of forming an oxide RO_4 or a salt K_2RO_4. The volatile metal osmium agrees with the requirements of this element very closely. Similarly, ruthenium may possibly be the element 100.

Finally, argon falls naturally into the place of element 20, and possesses, so far as is known, the properties to be expected of this element in position 20 in the new group. Argon and element 36 should be comparatively abundant in nature, while 84 and 132 should be scarce, but not more rare than selenium and tellurium.

On Mr. Reed's system, argon should be element 36, if it be monatomic as now believed, and not 20, as he assumes; the actual atomic weight found, 39·9, would

then indicate the possibility of the presence in argon of some small quantity of element 84 or element 132. It is remarkable, also, that if helium has the atomic weight 4, it falls naturally in this group, and that its atomic weight deduced from the observed density is somewhat greater than this number. If this difference should be due to the presence of some small quantity of element 84, then the spectroscopic evidence leading to the conclusion that argon and helium contain a common constituent would be explained.

[NATURE.]

THE ELECTRICAL MEASUREMENT OF STARLIGHT.

THAT the light of a star is able to produce at the surface of the earth a measurable effect, other than the action on a photographic plate, is a fact which was published in these pages in January last year. The light of stars and planets produces two effects—the one photographic and the other electric. The first—which has, of course, been known for many years—is slow in its operation; the second—which was discovered only a year ago in Mr. Wilson's observatory at Daramona, Westmeath—is almost instantaneous.

In order to obtain the electrical effect, a photoelectric cell of extremely great sensitiveness to light is employed. Such a cell is constructed with selenium, aluminum, and the liquid œnanthol. If we take a strip of clean aluminum—say half an inch long, one-tenth of an inch wide, and thick enough to be fairly stiff—lay it on an iron plate which is heated by a Bunsen flame, and place on the end of the strip a very small particle of selenium, this selenium will melt and form a small black globule of liquid. Let the flame be now withdrawn, and the globule of melted selenium spread over the end of the aluminum strip, by means of a hot glass rod, so that it forms a thin uniform layer of area about 0·1 of an inch square on the end of the strip, and let this dark layer cool to a few degrees below its melting point (about 217° C.) Now apply heat again to the under surface of the iron plate until the aluminum strip becomes nearly hot enough to remelt the layer of selenium. In this process the color of the layer will gradually change from black to a grayish brown. When it is just on the point of melting, withdraw the heat and blow over its surface; this will instantly check the tendency to melt, and will leave the surface of the selenium in the state in which it is most sensitive to light. If this strip (or rather its selenium-covered end) is immersed in a glass tube containing acetone or œnanthol, and connected with one pole of a quadrant electrometer, whose other pole is connected with a platinum wire sealed into the glass tube, we have a photoelectric cell, in which the action of light falling on the selenium layer results in giving the selenium a positive electric charge and the liquid a negative one, the former charge being conveyed to one pole of the electrometer by the aluminum plate, and the latter to the other pole by the platinum wire sealed into the cell.

Roughly speaking, the difference of potential produced in such a cell as this by ordinary diffused daylight is something between one-third and one half of a volt.

Such were the seleno-aluminum cells used in the measurement of starlight in January, 1894, the liquid in them being œnanthol. This liquid was found to be better than acetone (which had been previously used), not only because of the greater ease with which it can be sealed up in glass tubes, but because it does not act chemically on selenium, which acetone seems to do sooner or later. But it is obvious that a cell formed in this way contains an element of inconstancy; for, the strip of aluminum will at the same time convey to the insulated pole of the electrometer the positive charge generated by light in the selenium and a portion of the negative charge imparted to the liquid, so that the effective E. M. F. is less than it should be; and, again, there will be currents circulating perpetually between the selenium and the back of the aluminum strip, and such currents deteriorate the cell. Hence it happened that such cells always fell off in strength after about six hours. They sufficed, however, to show very easily measurable electromotive forces from the light of the planets, and even from the light of Sirius.

Shortly after January, 1894, a very notable improvement was made in the construction of the cells, this improvement resulting from the perception of the cause of deterioration above explained. Instead of a strip of aluminum as a base for the selenium layer, the end of an aluminum wire, about one millimeter in diameter, was used. This wire was inclosed in a glass tube (A, B, in the figure), into which it fitted tightly, one end of the wire being flush with an end of the tube. On this end was deposited the layer of selenium, with the same process of heating as that already described. The other end of the aluminum wire inside the glass tube was connected with a fine platinum wire, P, which emerged from the second end of the tube, and which formed the selenium pole of the photoelectric cell.

In this way the liquid is kept out of contact with the aluminum wire, and the deteriorating local currents in the cell are avoided, if the glass tube exactly fits round the aluminum wire; but this desirable result has not yet been perfectly attained, the liquid finding its way into the tube after some considerable time. However, in this way have been constructed cells which have remained constant for about three weeks.

In the figure, C C is a cork in which the glass tube, B, containing the aluminum wire at the end, A, and the attached platinum wire, fits, this cork fitting tightly into the side of the glass cell which contains the liquid. The tube, B, passes close up to a quartz window, Q Q, cemented to the cell opposite the cork, C C. The light of the star is received on the window, Q Q, and is made to fall on the selenium layer at the end, A, of the tube, B. A platinum wire, P', is sealed into the bottom of the glass cell, and conveys the charge taken by the liquid to one pole of the electrometer, while the platinum wire, P, conveys the charge taken by the selenium to the other pole of the electrometer; S is a ground stopper at the top of the cell, where the liquid is poured in.

This cell is fitted into a holder which can be fixed to a telescope in place of the eyepiece; and this cell holder allows of the adjustments which are necessary to bring the point, A, to the position of the image of a star.

This is the form of photoelectric cell with which, in conjunction with Prof. Fitzgerald and Mr. W. E. Wilson, I measured the electromotive forces of the lights of Jupiter, Saturn, Vega, Arcturus, Regulus, Procyon and some other stars last April, in Mr. Wilson's observatory at Daramona, Westmeath. The telescope used was Mr. Wilson's 2-feet reflector.

In order to give a notion of the sensitiveness of the cell to light, I may say that if an ordinary paraffin candle is held at a distance of 9 feet from the window, Q Q, it will produce an electromotive force of about 0·03 volt; or, to put the matter differently, suppose an ordinary quadrant electrometer, of Clifton's pattern, charged so that a Daniell cell gives a deflection of 400 divisions on the ordinary scale (placed at a meter distance); then the light of the candle at 9 feet falling on the photoelectric cell would give a deflection of twelve divisions, and the deflection varies inversely as the distance of the candle.

Now the light of Vega as concentrated in the 2-feet telescope gives a slightly greater deflection than the (of course unconcentrated) light of the candle; so that we are evidently dealing with easily measurable quantities.

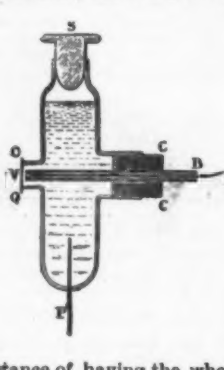
The cell is sensitive to all the rays of the spectrum, but the maximum effect is produced by the yellow. It is sensitive to rays considerably below the visible red and beyond the blue.

The light of Arcturus was found to give 0·82 of the E. M. F. produced by the candle at 9 feet; the light of Saturn, 0·56, which was also about the value of the light of Regulus. Unfortunately neither Sirius nor Capella, nor any star in Orion, nor any in the Great Bear, was available for our observations; but these we hope to include, before long, in the list of measured stars.

It will be observed that in this electrical measurement of starlight we do not measure currents, but electromotive forces—we do not use a galvanometer, but an electrometer; and an electrometer of small capacity was specially constructed for these experiments with the aid of the government grant dispensed by the Royal Society.

It is not desirable to allow the light to generate currents; the electrical charges must be allowed to flow back into the cell, so that it may not be temporarily deteriorated during the observations. Hence the preference for the electrometer.

The space at my disposal will not allow of my entering into many details; but I may mention, in particular, the importance of having the whole of the sensitive surface in the cell covered by the light of the star. It matters not to the value of the E. M. F. produced how far behind the focal image of the star the sensitive surface, A, is placed—provided that the image of the star just covers the surface, A. This is essential in all photoelectric cells, and also in thermopiles; and the neglect of this condition may partly explain the failure of attempts to obtain thermoelectric indications from the stars and planets, although we should scarcely expect success from methods which aim at measuring merely a very limited portion of the radiation, viz., the heat or infra red. The photoelectric cell integrates the whole energy of the radiation on the sensitive surface; and the square of the observed E. M. F. is the measure of this incident energy.



It is interesting to know how the photoelectric measures, so far as they have gone, compare with the photometric measures of "magnitudes" hitherto employed by astronomers. In the latter, if B and B' are the "brightnesses" of two stars of the magnitudes m and m' respectively, we have by definition

$$\log_{10}\frac{B}{B'} = \frac{4}{10}(m' - m) \qquad (1)$$

This equation defines merely the difference of the magnitudes, and the definition is quite arbitrary. The essential things are B and B'. How are they measured? The photoelectric method says that they are E^2 and E'^2, the squares of the electromotive forces generated in a given cell by the lights of the two stars. The photometric method says that they are measured by the thicknesses of certain interposed glass prisms which extinguish the lights, or by polarizing apparatus which render the shades of the transmitted lights "equal." Hence we may expect, perhaps, a fair amount of agreement between the two methods, if we are comparing two or more stars of the same color. Thus, in the photoelectric method, we have for any two stars

$$m' - m = 5\log_{10}\frac{E}{E'} \qquad (2)$$

Applying this to Arcturus and Regulus, and taking the magnitude of the former as 0·2, we find the magnitude of Regulus to be 1·33. In Miss Clerke's "System of the Stars" (appendix), Regulus is quoted as 1·4, Arcturus being 0·2.

Comparing in the same way Procyon and Regulus, the latter being taken as of magnitude 1·33, the magnitude of Procyon would be 0·46. Miss Clerke quotes Procyon as of magnitude 0·5.

But no agreement between the two methods is to be expected when two stars of different colors are compared. The photometric method of equalization seems to be just as meaningless as the ordinary "grease spot" method of attempting to equalize a blue and a red light! In this case the only intelligible comparison of two lights consists in measuring the energies which they radiate per unit time per unit area at a given distance—just, for example, as Newton's second axiom defines two masses to be "equal" when the same force produces the same acceleration in both; an equality which is real if the substratum at the basis of all bodies is the same, but merely conventional if it is not.

If the distance of a star is known, we can determine its intrinsic energy, i. e., the quantity of energy which it radiates into all space per unit time.

Thus, let I be the intrinsic energy of a star whose distance from the earth is R; let E be the electromotive force of its light as measured by the cell; let i, r, e be the analogous quantities for a candle or any other chosen source of light; and let A and a be the areas of the aperture of the telescope and the selenium surface in the cell. Then we have

$$\frac{I}{i} = \frac{R^2 . E^2 . a}{r^2 . e^2 . A} \qquad (3)$$

Let us take, for example, a result which Prof. Boys recently told me that he had obtained. He found, in conjunction with Mr. Watson, of South Kensington, that if the light of a standard candle was observed across a valley and almost in a line of sight of Arcturus, the light of the candle and that of the star seemed to be equal when the candle was at a distance of five-eighths, or 0·625 of a mile.

Now, let x be the distance at which the candle light seems to be as bright as that of the star. Then

$$\frac{I}{R^2} = \frac{i'}{x^2}; \qquad (4)$$

And if D and d are the diameters of the telescope aperture and the circular layer of selenium in the cell, we have from (3)

$$x = r\frac{eD}{Ed} \qquad (5)$$

Put, now, $r = 9$ feet, $e = 10$, $E = 8·2$, $D = 24 \times 25$ millimeters, $d = 2$ mm., as in our experiments, and we find

$$x = 3,300 \text{ feet, nearly}$$
$$= 0·62 \text{ mile.}$$

This agrees remarkably well with the observation of Prof. Boys. GEORGE M. MINCHIN.

ELECTRIC MINING PLANT.

THE operation of mining machinery by electricity avoids in so many cases a great deal of difficulty and loss of efficiency that the rapid extension of this mode of working is not surprising. The Engineer, London, says: The electric power plant erected at the Margaret Pit for Lord Durham is a good example of the application of electricity to the various purposes for which power is required in a colliery, and is one of the most complete installations which has been running for any length of time. This system of power transmission lends itself particularly well to mining work where winding, hauling, pumping, etc., have to be performed at a considerable distance from the top of the pit, and this class of work has generally been done by horses, continuous ropes, compressed air, and even by steam engines in some cases, the boilers being a long distance along the roads from the bottom of the shaft to the workings. At Margaret Pit, where the machinery was put down by Messrs. W. T. Goolden & Company—now Messrs. Easton, Anderson & Goolden, Limited—the generating plant is placed in a fine engine room seventy yards from the top of the shaft. The two engines are by Messrs. Willans & Robinson, and are of the H. H. size, each developing about 114 indicated horse power, at 320 revolutions per minute. The engines are arranged one at each end of a line of shafting, and either engine can be connected to it by a clutch, which consists of a coupling disk sliding on the shaft having four projecting pins which enter four corresponding holes in the engine fly wheel, and can be drawn out when power from the engine is not wanted. The dynamos are driven by link belts from the shafting, and are four in number, two being wound for high volts for power transmission, and two, which are of a smaller size, being used for exciting and lighting at the bank and at the pit bottom.

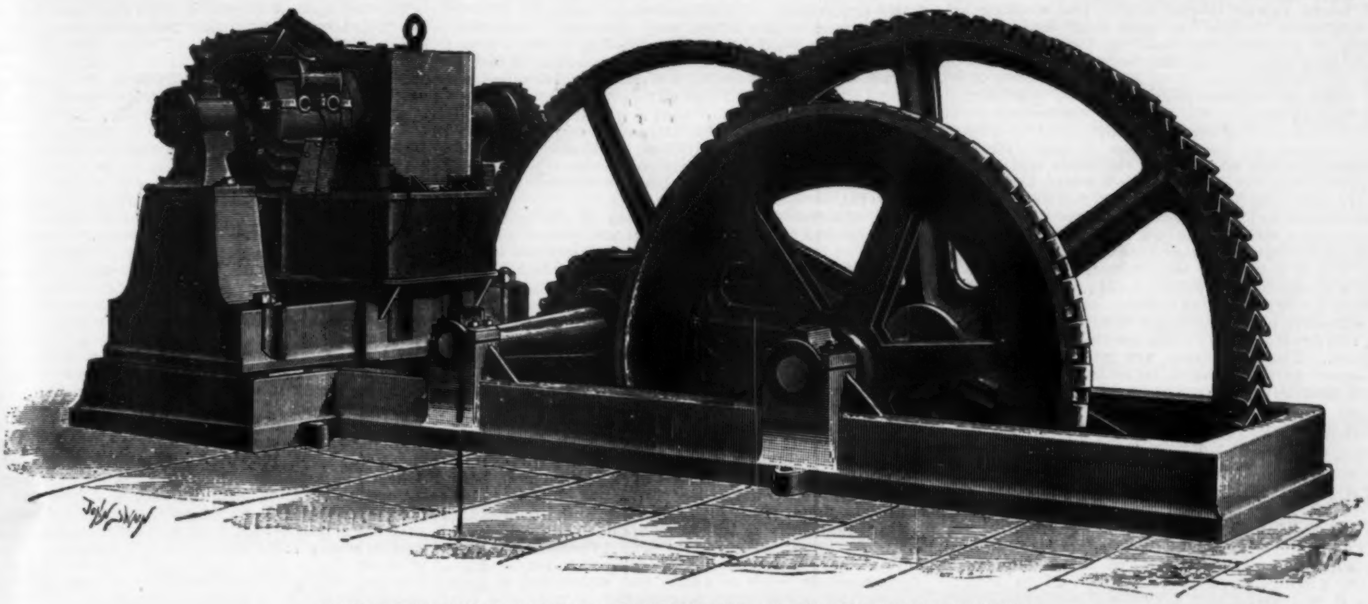
The power dynamos are of the Goolden C. G. type, having Gramme armatures, and are fitted with carbon brushes. Each machine is capable of giving at 780 volts, 79 amperes at 500 revolutions per minute, and is separately excited. The lighting dynamos are of the Goolden 9 F. D. type, with drum armatures, and are compound wound, each giving at 100 volts, 90 amperes at 1,200 revolutions per minute. The current from the dynamos is taken to two fine switch boards, one for the lighting circuits and the other for the power mains, the latter being so fitted that there is no fear of any one getting a shock, as all switches are inclosed so long as the power is on, the act of switching on boxing up the switches. The lighting consists of arc and incandescent lamps at the bank, and incandescent lamps at the pit bottom. The pit bottom is an extremely fine one, with plenty of head room, and is arched over with white glazed bricks, which, with the electric light, gives it more the appearance of a railway station than a coal pit.

The original electric power plant consists of a pump, a continuous hauling engine—the general arrangement being shown by the engraving—and a winding engine. A small pump has since been supplied by the same makers. The distances are as follows: From generating station to top of shaft, 70 yards; depth of shaft, 290 yards; bottom of shaft to distributing center, 387 yards. The cables here fork, one part leading to the pump, which is at a lower level and is 650 yards away, the other on to the hauling engine, 1,290 yards, and from hauling engine to winding engine, 1,300 yards. The total distances from the generating station are: Pump, 1,337 yards; hauling engine, 1,977 yards; winding engine, 3,277 yards. The pump is of the horizontal

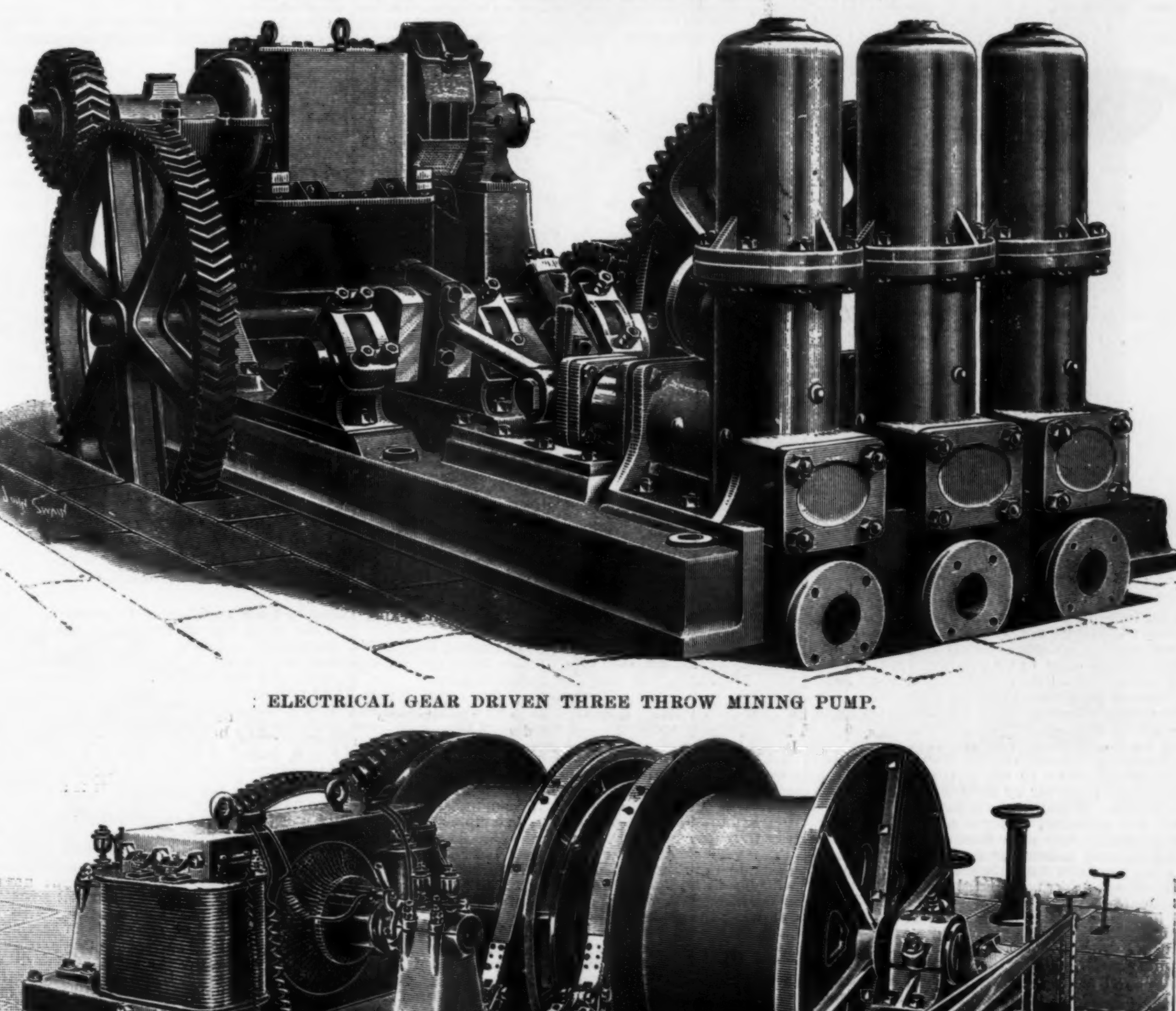
three-throw ram type, driven through double helical gears by a Goolden O. G. motor, having a Gramme armature and carbon brushes, inclosed in gas tight covers. The following test of this pump, taken in place, is of interest: Water pump per minute, 178 gallons, head 257·5 feet, volts 580, amperes 23, giving an efficiency =

$$\frac{\text{Water horse power}}{\text{Electrical horse power}} \times 100 = 78 \text{ per cent.}$$

The hauling engine is driven by a Goolden motor, having a Gramme armature and carbon brushes inclosed in gas tight covers. This is shown by the engraving. The continuous rope is worked by a Hurd clip pulley through double helical gears driven



ELECTRIC GEAR DRIVEN CONTINUOUS ROPE HAULING ENGINE.



ELECTRICAL GEAR DRIVEN THREE THROW MINING PUMP.

ELECTRICAL GEAR DRIVEN WINDING ENGINE.

IMPROVED ELECTRIC MINING MACHINERY.

by a motor taking 610 volts, 58 amperes, at 650 revolutions per minute, and which is shunt wound, so that the speed varies very little with changing loads. When tested with a Prony brake, the ratio of power applied to the rope to the electrical power supplied to the motor was found to be 72·8 per cent. when supplying 25·5 horse power to the rope. The winding engine is used on a "staple" or short shaft leading from one seam to another, and has two winding drums, each raising a cage, so that the weight of the cages is balanced.

The motor is of the Goolden O G. type, shunt wound, with carbon brushes and gas tight covers. It is regulated by a reversing switch, actuated by a lever as on a locomotive, the variations of speed, starting and stopping, being all done by the same lever. The drums are driven by double helical gears, and brake drums are cast solid on the flanges of the rope drums. All switches are inclosed in gas tight cases, and where shunt machines are used, as in the hauling and winding engines, the fields are disconnected by a double pole switch, which inserts a non-inductive resistance in parallel with the fields before breaking, and leaves it connected, so that the extra current can die down without an excessive potential being raised. As a matter of fact, the 600 volt shunt fields are thus broken without a spark. These switches are interlocked, so that the armature current cannot be switched on until the fields are excited.

We are indebted to the Engineer, London, for the foregoing particulars and for our illustrations.

[From Engineering.]

THE ROTATION OF THE EARTH.

By M. F. O'Reilly, D.Sc.

The pendulum experiment associated with the name of Foucault was made in Paris in 1851. The object which the distinguished investigator had in view in devising it was to furnish a direct proof of the daily revolution of the earth round its axis. This rotational movement was, of course, not called in question, being supported, as it is, by a body of evidence that needs but to be considered in order to command belief.

There is, for instance, the analogy argument derived from the observed rotation of the sun and planets. It could not reasonably be supposed that the earth would be exempted from the law to which every other member of our system is subjected. Indeed, such axial immobility on our part would lead to consequences of a startling nature. The succession of day and night would inexorably demand the revolution round us of all heavenly bodies, be they near as Mars and Venus, distant as Neptune, or remote as the stars of the Milky Way. They would have to effect their daily cycle round us as if held together by rigid, even though unimaginable bonds. Without exception, they would all revolve with the selfsame, uniform angular velocity.

When from angular we pass to consider the linear velocities which such geocentric revolution would require, we meet numbers not only startling, but appalling indeed. We would thus find our nearest stellar neighbor α Centauri* whirling by with the velocity of light; the interesting σ Lyræ would be devouring its way still more eagerly, while the speed of the far off worlds, that only just succeed in recording their existence on a photographic film, baffles conception.

Terrestrial as well as celestial mechanics also furnishes unanswerable arguments against our axial quiescence. Daily experience shows that small masses revolve round large ones, and not vice versa. It is therefore no less repugnant to common sense than contrary to the fundamental facts of dynamics to suppose that the sun, giant planets like Jupiter, and vast orbs like Sirius, are compelled to revolve round our small planet.

Again, the ellipsoidal figure of the earth points to rotation as the cause of its departure from perfect sphericity; and the same axial revolution is needed to explain the difference known to exist between the apparent and the absolute value of gravity at any place. This difference† amounts to 0·1112 ft.-sec.² at the equator, and is precisely the diminution $\frac{v^2}{r}$ produced by the central reaction properly called centrifugal force, calculated on the assumption that the earth turns on its axis once in twenty-four hours.

* Its nearness may be inferred from the fact that its light takes 4½ years to reach us.

† The absolute g at the equator is 32·201 ft.-sec.²; the apparent g is 32·0898 ft. sec.²

A careful scrutiny of the path of falling bodies discloses another peculiarity attributable solely to rotation. It is noticed that when the fall is considerable, the point which the body reaches is perceptibly displaced from the vertical. Experiments of this kind were attempted in several countries; those that command the greatest confidence were made in 1832 by Reich in one of the mines near Freiberg, in Saxony. He selected a shaft 520 ft. deep, and in it conducted a series of 106 observations. In every case the deviation was unmistakably toward the east, its average value being 1·114 in. Calculation gave 1·087 in.

Such observations show that the trajectory of bodies falling from a height under the action of gravity is not a straight line, but an arch of an attenuated parabola. The curved character is due to the excess of the easterly velocity of the point of departure over that of the point of arrival.

The experimental demonstration of the earth's rotation devised by Foucault is of much readier application. The method is original, the apparatus simple, the results conclusive. No doubt the young French physicist caused some astonishment in professorial circles when he announced that a heavy mass, swinging like a pendulum, could be made to show:

a, that the earth does rotate;
b, the direction in which it rotates, and
c, the speed with which it rotates.

But Foucault, though only 32 years of age at the time, had already done remarkable work. In 1845, he daguerreotyped the sun, thereby inaugurating the era of celestial photography. In 1849, he described the darkening of the D line in the spectrum of the electric arc when crossed by a solar beam, being thus throbbingly near discovering the eagerly sought rationale of spectrum analysis. In 1850, he measured within the limits of his work room (!) the velocity of light. At the same time he confirmed the theoretical deduction that a ray should be delayed in traversing a dense medium such as water, and succeeded in showing that the amount of retardation is precisely that required by the wave theory. This memorable piece of scientific work is held universally to be coequal in importance with Fresnel's crucial test of the wave theory of light as well as with the brilliant prediction of conical refraction by Sir William Hamilton and its experimental verification by Dr. Lloyd.*

The publication of such results enhanced Foucault's reputation and won for him, in due time, the distinction of foreign member of the Royal Society.

The announcement, therefore, of his novel demonstration of the earth's rotation excited considerable expectation. The equation of motion of the pendulum was of peculiar interest to mathematicians, even though they were unable to solve it completely on account of the formidable difficulties it presents. Physicists took up the resulting integrals and promptly submitted them to the test of experiment. The pendulum was found to be as sound in principle as satisfactory in its performance.

This very suggestive experiment has recently been repeated in Trinity College, Dublin, and in De la Salle Training College, Waterford. The details of the latter are before us, and to them we shall refer in the following brief exposition of the phenomenon, and elementary dynamical principles, of a Foucault pendulum.

A general view of the Waterford apparatus is given in Fig. 1. The bob weighs 19 lb., and hangs from a steel pivot by a wire 37·5 ft. long. When started accurately by a blow through its mass center, the pendulum swings to and fro, making 50 complete oscillations of 1 deg. amplitude in 339 seconds.†

The forces called into play are

a. The weight of the vibrating mass acting downward.

b. The extra pull $\left(m\frac{v^2}{r}\right)$ on the pivot, due to the circular motion; and

c. The reaction of the pivot.

* Both of Trinity College, Dublin.

† An approximate value of the intensity of gravity may be deduced from these data. For

$$t = 2\pi\sqrt{\frac{l}{g}}\left(1 + \tfrac{1}{16}\sin^2\theta\right),$$

whence g = 32·206 ft.-sec.²

Clairault's formula is

$$g = G\,(1 + 0{\cdot}00513\sin^2\lambda).$$

Applying it to Waterford, we get

$$g = 32{\cdot}19 \text{ ft.-sec.}^2$$

As the last two act along the wire in opposition to each other, we have at any moment but two directions to consider. These determine a vertical plane in space, and it is in this plane that the pendulum effects its oscillations with unvarying precision as to time and position.*

The rotation of the earth gives rise to no force capable of deflecting or turning this plane round a vertical axis. Whence it follows that, once determined by the initial circumstances of motion, it will undergo no variation other than that involved in its being carried, equally with all its surroundings, round the diurnal circle of the place of observation. The horizontal table is indeed turning round a vertical axis, unnoticed by the spectator; but not so the plane of oscillation; it continues throughout to be absolutely unaffected by any such motion.

It frequently happens that casual observers of the phenomenon, finding the last statement difficult of belief, look about for some simpler mode of explanation. They are not long in discovering one. With emphatic assurance they account for everything by saying that the pivot revolves, and, in revolving, carries the plane round with it. Now, the pivot in our case, as Fig. 1 shows, is a mere point supported by a steel cup. Even if this cup, on account of its attachment to the ceiling, be forced to rotate, a moment's reflection will suffice to show that it has no power whatever to coerce the point and the heavy pendulous mass into accompanying it.

Others, with greater plausibility, affirm that the bob and the wire must rotate round their common axis for the very same reason that the table does. This we concede only to have the opportunity of saying that even such rotation would make no impression on the position of the plane of oscillation. To realize this, suspend a ball by a thread and set it swinging, taking care to observe the arc in which it vibrates. Then stop it, twist the thread, and start it precisely as before. The ball will now spin round the thread, but will keep accurately to the same arc of vibration as before. The oscillation and the spin coexist, but without mutual interference.

The irrotational character of the plane of vibration round a vertical axis being established, let the pendulum be drawn aside and tethered as in Fig. 1. This is the usual way of starting it, the impulsive method presenting practical difficulties. When perfectly at rest, the thread is burnt, and the bob starts off accurately (we shall suppose) on its course. In every beat the projection of the pointer will coincide very nearly with a diameter of the horizontal circle. If the earth were stationary, this diameter would be the same from start to finish; but it is not. The north end of the arc, Fig. 2, seems to move slowly round toward the east side of the table. This is the Foucault phenomenon, and we shall now see that it is a direct result of our own axial rotation.

Fig. 4 shows the table in three positions, each separated from the other by a brief interval of time. It is carried round from west to east as the arrow shows; but not, however, by a parallel motion of all its parts, for it will be observed that a point anywhere on its southern edge will move eastward a little faster than the point diametrically opposite. This is equivalent to saying that, while the table is carried eastward by the rotation of the earth, it turns round in its own plane with a movement equal to this difference. Since the southern edge has the greater linear velocity, the direction in which the table will rotate is from east to west passing through north, i. e., counter-clockwise. See the arrow in Fig. 1, also in Fig. 5.

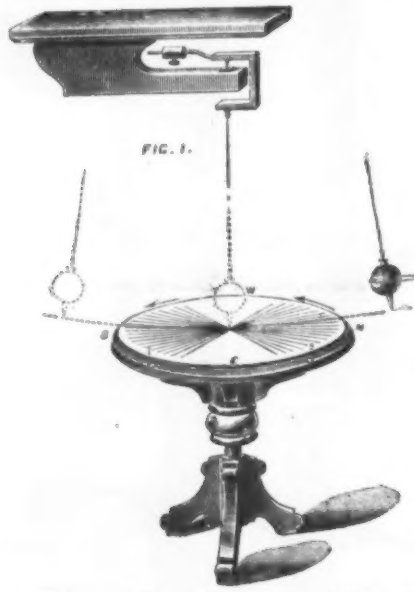
It is not the pendulum, then, that swings round toward the east, but it is the table itself that slowly and imperceptibly turns in the opposite direction.

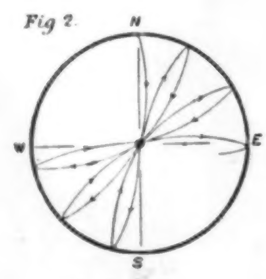
The long straight lines in Fig. 4 are tangents drawn through the middle of the table, meeting the earth's axis, produced, at P. By joining C with this middle point, it will be readily seen that the locus of P is such that the angle C P W is equal to the latitude of the place.

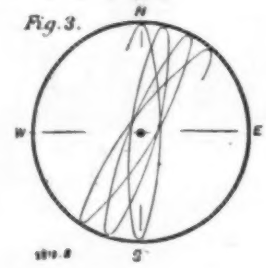
If the pendulum is started in the meridian as shown at W, the plane of vibration, having undergone no rotation whatever round a vertical axis, will be represented by the dotted lines, and the displacement of the table by the angle between the dotted diameter and the corresponding tangent. This angle, evidently, increases with the time.

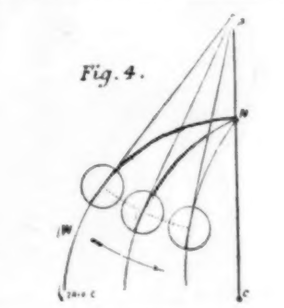
If the experiment were made in a lower latitude than Waterford, the angle C P W would correspondingly

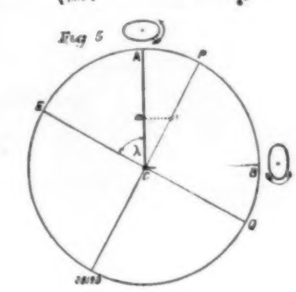
* The time is indeed subject to an increment of change, which, in the most favorable circumstances, might amount to one second in a century. It is due to the component Cn of the axial rotation. See infra.











decrease, and the point P would recede from N. The differential movement would necessarily diminish, and, with it, also the angular rotation.

If we proceed to a station on the equator, the angle C P W will vanish, and the point of convergence P move off to infinity. The tangents will then be parallel to one another, the differential movement will disappear, and the table will not swing round its center at all while performing its daily circuit of 25,000 miles.

If, however, we journey up to the pole, the angle C P W will be 90°, the point P will come down to N and coincide with the middle of the table. The differential velocity will then be a maximum, the table making a complete rotation round its center every day.

Another and readier way of realizing this phenomenon is to connect it with the angular velocity of the earth. In Fig. 5, A is the place of observation; C P being the polar radius, and E C Q the equatorial diameter in the meridian plane of A, the angle E C A is the latitude of the place. Every point on the earth's surface moves hourly through the same number of degrees. We know from Rigid Dynamics that this angular velocity round the polar axis C P, represented in magnitude by C o, may be resolved into C m and C n round C A and C B, two radii at right angles to each other. The rotation effects observed at A are due entirely to the component C m. The other component C n is incapable of producing even an infinitesimal deflection of the plane of oscillation round a vertical axis. Now

$$\begin{aligned} \text{C m} &= \text{C o} \times \cos \text{m C o} \\ &= \omega \sin \lambda \end{aligned}$$

where λ is the latitude of A and ω the angular velocity of the earth, viz., $\dfrac{360}{\text{23 hours 56 min. 4 sec.}} = 15{\cdot}04^\circ$ per hour.* As the daily motion of the earth is contrary to the apparent course of the sun and stars, it must take place from W to E. Hence the table shown at A turns round its center as indicated, and with a velocity depending, as we see, on the latitude.

At the equator

$$\lambda = 0^\circ \therefore \text{C m} = 0.$$

At such places, therefore, the pendulum would swing constantly over the same line, and the table would have no movement of rotation at all in its own plane.

At either pole

$$\lambda = 90^\circ \therefore \text{C m} = \omega \sin 90^\circ = 15{\cdot}04^\circ.$$

That is, the table would turn round with the angular velocity of the earth. In our hemisphere, an observer would describe the motion as counter-clockwise; the same observer would, of course, describe the motion of the table at the antipodes as clockwise. This follows from his own relative reversal.

The latitude of Waterford, as communicated by the *Ordnance* Survey, is 52° 15 min. 34 sec. Hence

$$\begin{aligned} \text{C m} &= \omega \sin \lambda \\ &= 15{\cdot}04^\circ \times 0{\cdot}7908 \\ &= 11^\circ \text{ 53 min. 37 sec.} \end{aligned}$$

This is the theoretical value of the hourly rotation of the table at Waterford, and also at all places lying on the same parallel of latitude.

The number obtained at De la Salle Training College is in close agreement. Thirty-three observations were made between February 5 and March 23, the mean being 11° 48 min. A complete rotation of the table would thus take place in

$$\frac{360}{11{\cdot}8} = 30\tfrac{1}{2} \text{ hours.}$$

The angular rotation may be used for roughly finding the latitude of the place. Thus

$$\begin{aligned} 11{\cdot}8 &= 15{\cdot}04 \times \sin \lambda \\ \therefore \sin \lambda &= 0{\cdot}7908 \end{aligned}$$

whence

$$\lambda = 51^\circ \text{ 41 min.}$$

We can also deduce the time required by the earth to revolve round its axis; in other words, the length of the sidereal day. For

$$\begin{aligned} 11^\circ \text{ 48 min.} &= \omega \sin \lambda \\ &= \omega \sin 52^\circ \text{ 15 min. 34 sec.} \\ &= \omega \times 0{\cdot}7908, \end{aligned}$$

whence

$$\omega = 14{\cdot}922^\circ \text{ per hour;}$$

and the length of the day

$$= \frac{360}{14{\cdot}922} = \text{24 hrs. 7 min. 30 sec.}$$

The following table from a chart in the Science Section of the South Kensington Museum shows the results obtained by other observers:

Place	Latitude.		Observed Hourly Motion.	Calculated Motion.	Observer.	Deduced Time of Earth's Rotation.		
	deg.	m.	deg.			h.	m.	s.
Ceylon ..	6	56	1.870	1.815	Schaw, Langprey	23	14	20
New York ..	40	44	9.733	9.814	Loomis	24	8	9
Providence (R.I.)	40	49½	9.955	9.833	Carswell, Norton	23	38	29
New Haven (Conn.)	41	18½	9.970	9.929	Lyman	23	50	7
Geneva ..	46	12	10.522	10.856	Dufour, Wartman	24	41	39
Paris ..	48	50	11.300	11.323	Foucault	23	33	57
Bristol ..	51	27	11.785	11.763	Bunt	23	53	2
Dublin ..	53	20	11.915	12.065	Galbraith, Haughton	24	14	7
Aberdeen ..	57	9	12.700	12.688	Gerard	23	48	29

It has been said that difficulty is experienced in getting accurate measurements of the angular rotation. This would not be the case if the mass center of the pendulum always passed through the position it occupied when at rest. The pointer would then necessarily sweep over the center of the graduated circle at each beat (Fig. 2), and the corresponding position of the plane of motion relative to the table could always be read off with facility and precision. But the plane of vibration is subject to several disturbances which render it somewhat difficult to get reliable readings.

The first of these arises from the manner in which the pendulum is usually started. While the bob is tethered, as in Fig. 1, it shares the rotation of the room just as the walls, furniture, and inclosed air do. Therefore, when set free by burning the slender attachment, the mass center of the bob will not pass through the position it occupied when hanging at rest, but will, in our hemisphere, swing a little to the right of it. The suspending wire will not vibrate in a circular arc, but will sweep out the surface of a cone, having, it is true, an exceedingly narrow and elongated elliptical base.

The second agent that interferes with the motion of the pendulum is the resistance of the air. This resistance, for small velocities, varies as the first power of the speed, and acts along the tangent to the elliptical curve which the bob is describing. The dynamical effect is a small retrograde motion of the major axis of the ellipse. Indeed, it is clear that such a resistance must cause the bob to stop and turn over before it attains the previous greatest elongation.

This interference with the normal performance of the apparatus is neutralized, in great measure, by the very motion of the bob itself. When the pendulum swings through a small angle, the displaced air has not time to return to its quiescent state before the bob is round again. The air particles have not yet entirely lost their onward momentum, and, as a consequence, they offer less resistance than when still. The retrograde motion is thereby lessened, and may, indeed, with proper care, be reduced to an unimportant quantity.

While the displaced air tends to minimize one disturbance, it gives rise, unfortunately, to another. For the resistance to motion offered by this agitated air will no longer act through the mass center of the bob, but eccentrically, and in such way as to open up and broaden out the ellipse. This greatly increases the difficulty of determining with accuracy the position of the major axis, the rotation of which, however, measures the angular displacement of the mean plane of vibration.

The character of the motion actually observed with a Foucault pendulum is roughly shown in Fig. 3. For the sake of diagrammatic clearness, the minor axis is greatly exaggerated, for even after an hour's oscillation, the ellipse remains extremely attenuated.

It is not possible to avoid completely the above disturbances, but their relative importance may be greatly reduced by making the pendulum long, and the bob massive.

In the Waterford experiments we notice that the readings were taken within a short time from starting, that is, before the disturbing forces arising from the rotation and viscosity of the air could produce any marked effect. The pendulum was started sometimes from N toward S and sometimes in the opposite direction. Most of the observations were made at night or on afternoons when the students were at the practicing school, or out at the agricultural station, obviously for the purpose of avoiding further complications from draughts and mechanical vibrations.

When Foucault made the experiment, he availed himself of the favorable physical conditions of the Pantheon. His pendulum weighed 28 kilogrammes (62 lb.), and was 64 meters (210 ft.) long. It is necessary to use a massive sphere, for the reason given above, and also that the motion may not inconveniently decrease before the effect has been determined. The suspending wire is made as long as possible, in order to get considerable linear, with small angular, displacement. When the amplitude does not exceed 3° or 4° on either side of the mean position, the vibrations are isochronous, a condition which is assumed in deducing the rotational period of the earth from observations limited to some minutes' or to an hour's duration. Besides this, when the pendulum is long, it swings slowly. This facilitates the readings. Foucault's pendulum required 8 seconds for each beat, that in Waterford 3½ seconds.

It is to Foucault's fine genius that we are also indebted for a modified form of the gyroscope. He was first to use this peculiar contrivance for the purpose of giving another direct and ocular demonstration of the revolution of the earth on its axis.*

Leon Foucault died in Paris, February 11, 1868. Though only 49 years of age, he did monumental work, and has left a name associated with optical measurements of primary importance, synonymous with "eddy" currents in electricity,† and intimately linked, as we have seen, with the dynamics of our globe.

WHITE BLACKBERRY ICEBERG.

THIS new blackberry was raised by Mr. L. Burbank, of Santa Rosa, California, by crossing a variety named the Old Crystal White with Lawton, which in America is considered the most productive blackberry known. The berries of Iceberg, as may be seen from the engraving herewith, are large and freely produced. They are said to be delicious in flavor and so transparent that the seeds, which are remarkably small, may be seen in the berries when ripe. The clusters of fruit are said to be very large and as firm as those of Lawton. We understand that this variety will be put into commerce by Messrs. Pitcher & Manda, of Short Hills, New Jersey.—The Garden.

THE WHITE BLACKBERRY ICEBERG.

POCKET GOPHERS OF THE UNITED STATES.

IN Bulletin No. 5 of the United States Department of Agriculture, Mr. Vernon Bailey gives an account of the habits and life history of the pocket gophers of the United States, which contains a number of interesting facts and observations derived from various sources.

These curious little rodents live underground in burrows which they tunnel in the soil. When working their way through the earth, they use the upper incisors as a pick to loosen the ground, while the fore feet are armed with strong curved claws for digging. When a sufficient quantity of soil has accumulated behind an animal, he turns in the burrow and pushes it out in front until an opening in the tunnel is reached; the earth is here discharged, and forms a hillock similar to the hills thrown up by moles.

Gopher burrows are extended and added to year by year, and the course is marked by the hills of soil brought up to the surface. Gophers do not hibernate as has been commonly supposed, but work steadily

* The true time of the rotation of the earth is the sidereal day. It contains 86,164 seconds of mean solar time.

* Dr. Edward Sang, a civil engineer of Edinburgh, pointed out in 1836 how the gyrostat could be used to demonstrate the rotation of the earth, but went no further. Foucault independently discovered this application of the gyroscope, and successfully carried out the experiments in 1851.

† Foucault did not discover those currents, but made some curious experiments, especially on their heating effects.

throughout the winter. They do a great deal of good in mixing the soil, and in this way are probably most useful on poor or uncultivated ground. But, on the other hand, in agricultural districts the animals are highly injurious; they devour potatoes and other tubers and roots in large quantities, as well as corn, wheat and other farm crops, and they destroy great numbers of fruit trees by gnawing off the roots.

Gopher burrows also often do a great deal of damage in meadows or on the banks of artificial water courses. So great is the harm done by gophers, that in many districts bounties have been offered for their capture. One of the most striking features of pocket gophers is their possession of cheek pouches opening outside the mouth. It is commonly supposed that these pouches are used for carrying earth out of the burrows; but Mr. Bailey's investigations lead him unhesitatingly to the conclusion that this view is erroneous; they are used only for carrying food—pieces of potato and roots, leaves, etc.—to be eaten at ease in the seclusion of the animals' burrows, or to be stored up for use in the winter. The food is passed into the pouches by the fore feet, and the animals empty their pockets by pressing the sides of the head with the fore feet from behind forward, so that the contents fall out in front of them. In disposition gophers are very fierce, and on the rare occasions on which they wander from their holes, frequently attack passers-by without any provocation. They are not very prolific animals, as is commonly stated, for only one litter of two or three young is produced in a year; but, although their rate of increase is slow, their mode of life protects them from many enemies which attack squirrels, mice and many other rodents. The pocket gophers of the United States belong to three genera, Geomys, Cratogeomys and Thomomys. Mr. Bailey gives two charts illustrating the distribution of these different genera and their constituent species.

FIFTY YEARS AMONG BIRDS.

All English ornithologists know something about the remarkable investigations carried on in the island of Heligoland, during a period of fifty years, by Herr Gatke; and some have read his account of them in German. A much wider circle will be grateful to Mr. Rosenstock, who has made an excellent English translation of the book, under the title of Heligoland as an Ornithological Observatory (Edinburgh, David Douglas). The large volume consists of three parts, of which the third gives a complete list of the 396 species of birds observed in Heligoland; the second, a short discussion of color changes without moulting; and the first, extending to 150 pages, an exhaustive discussion of the problem of migration. Herr Gatke's list has a double interest. It includes many extraordinary rarities, such as occasional wanderers from the far East, and even from America, like the American golden plover and the spotted sandpiper.

HOW BIRDS CHANGE THEIR COLOR.

As to the question of color change, every one knows that most birds have one dress for winter and another for the breeding season, but very few could give an account of the mode in which the change is accomplished. Herr Gatke explains that it is accomplished in three ways. The first and simplest is seen in the case of the finches, buntings, and other birds; it "consists in the shedding of the edges of the feathers of the winter plumage, which are mostly of a rusty gray color." The second, the stages of which can only be discovered by the microscope, consists "in a peeling off of the separate barbs of the feathers, whereby these are stripped of a thin, inconspicuously colored envelope, so that the purer and finer color previously concealed beneath the latter becomes exposed," while at the same time the texture of the feathers undergoes an alteration, and the tips are evenly rounded off. The pied wagtail and the linnet give examples of this process. Of the third method, which is chiefly seen in the gulls, sandpipers, etc., Herr Gatke speaks as follows:

The last and most wonderful process in the color changes of the plumage of birds, not attended by a renewal of the feathers themselves, consists in an actual, complete, and very striking change in the color of the feathers, without such alteration being brought about, or even assisted, by any changes in their texture.

As illustrating the climax of this process we may probably point to the change from a pure snow white to an intense glossy black or blackish brown. The first of these transformations is displayed in portions of the head and neck of the little gull, the foreneck and upper breast of the white and pied wagtails, the breast of the dunlin, and others. The latter change from white to blackish brown is observed in the necks and heads of the guillemots, of the razorbill, and undoubtedly also of the little auk.

THE MYSTERY OF MIGRATION.

But all these are matters of minor importance as compared with the phenomena of migration, and it is by his observations of the latter that Herr Gatke will chiefly be remembered. More than any one else he has observed the facts in their surprising regularity, but, as he confesses, he has come no nearer than any one else to an explanation of their secret. For fifty years he has watched the spring and autumn migrations, for he has lived at the place of all others where they can be observed, and he has recorded what he has seen with unwearied patience and with extreme acuteness. Here is his picturesque account of the October migration as seen at the lighthouse:

The darkness equally dense on all sides, amid which the lighthouse appears to float like some great luminous body; the broad beams which radiate from it in all directions, and in the dim air seem to stretch into infinite space; the consciousness of the near presence of the great sea around, and the complete absence of every sound in surrounding nature—all these combine to form a picture of the utmost solemnity and grandeur. This wide silence is first broken by the solitary low 'Zeep' (ezip) of the song thrush, and perhaps here and there the clear call note of the lark. Then again silence reigns for a minute or two, only to be once more suddenly broken by the far-sounding "Gluk" (ghee-eek) of the blackbird, soon followed by the manifold "Tir-rr" (tir-r r) of a swiftly-passing flock of sandpipers. The calls of the skylark rapidly increase in number, smaller and larger flocks of the birds being heard approaching and disappearing near and far. The hoarse "Etsch" (Etsh) of the snipe is accompanied by the clear, "Tuth" (tut) of the golden plover, the clear, loud "Klu-uh" (Klu-uh) of the gray plover, the wild, far-sounding cry of the curlew, the manifold "Shack-shack-shack" (Shack-shack-shack) of the fieldfare, the long drawn "Zieh" (tsee) of the redwing. Next, by the sound of hundreds of rapidly ejaculated cries, 'Tutt-tutt—tutt-tutt—tutt-tutt" (tutt-tutt—tutt-tutt—tutt-tutt), we recognize a long extending swarm of knots hastily pursuing its journey, accompanied by an incessant din of countless piping, rattling, and quacking voices unknown to gunner or fowler, and often reminding one of the melodious strain of a creaking cart wheel. Many of these, more particularly strident and harsher notes, however, evidently proceed from the heron and its many different relatives.

The whole sky is now filled with a babel of hundreds of thousands of voices, and as we approach the lighthouse there presents itself to the eye a scene which more than confirms the experience of the ear. Under the intense glare of the light swarms of larks, starlings, and thrushes career around in ever-varying density, like showers of brilliant sparks or huge snowflakes driven onward by a gale, and continuously replaced as they disappear by freshly arriving multitudes. Mingled with these birds are large numbers of golden plovers, lapwings, curlews, and sandpipers (Tringæ). Now and again, too, a woodcock is seen; or an owl, with slow beatings of the wings, emerges from the darkness into the circle of light, but again speedily vanishes, accompanied by the plaintive cry of an unhappy thrush that has become its prey.

Such a migration stream lasts through a whole long autumn night, and, under specially favorable conditions, may, as already stated, be repeated for several nights in succession.

We cannot pretend to follow Herr Gatke either through his facts or to his conclusions. It may, however, be remarked, that he has established many points beyond all possibility of question, and especially the fact that, as a rule, the young birds migrate, not after or with, but long before, the old ones; the young starlings, for example, travel six or eight weeks after leaving the nest. This clearly disposes of the theory that the route is a matter of traditional knowledge handed on from generation to generation. Herr Gatke examines all the theories, and, though he does not like to use the word instinct, he can come to no conclusion except that the birds are born with some faculty or sense which tells them on a given day that they must leave their feeding grounds, and that when that night falls they must, instead of going to roost as usual, fly high into the air and trust themselves to the unexplored, till, after a journey of hundreds or thousands of miles, they find themselves in Africa or wherever it may be. They travel very often at a height where it would be scarcely possible for a man to breathe; the condor, as is well known, can fly at a height of 40,000 ft., and in an ordinary migration, though from the nature of the case the exact height cannot be observed, there is reason to believe that many birds fly at half that altitude. Their velocity is very great, and Herr Gatke believes himself to have proved that even a little bird like the Northern bluethroat accomplishes its spring migration from Egypt to the north of Europe, a distance of 1,600 geographical miles, in a single night. This, however, is a point as to which it is surely lawful to ask for better evidences. The Virginian plover is known to fly habitually from its winter quarters in Labrador to northern Brazil; it flies across the sea, vast flocks having been met with 400 miles east of Bermuda, and therefore it must accomplish the whole journey of 3,200 miles at one flight. But if, as Herr Gatke maintains, 15 hours is the longest spell during which a bird is able to remain on the wing without taking sustenance of any kind, this would give the astonishing velocity of 212 geographical miles per hour. It seems scarcely credible, but what other explanation can be given?—London Times.

PARROTS NEED WATER.

To the Editor of the Scientific American:

The writer wishes to call attention through the pages of the Scientific American to the cruel but very universal custom of depriving the parrot family (including cockatoos, macaws, loras, and love birds) of water when in captivity, under the false impression that this liquid, so necessary to animal and vegetable life, is not good for them, but will kill them. This inhuman custom probably originated, like many others, in a lack of observation of nature and the use of common sense. It is almost unnecessary to say that in the wild state parrots (like everything else in nature), in order to live properly, are bountifully supplied with water, not only for drinking, but for bathing as well, and to use as needed.

Parrots die from drinking water because they are denied it in a pure state and given slops containing it to drink (altogether unnatural for them), but only in small quantities, and when they do get to water, they are the same as a human being, famished for water; if not restrained, are liable to kill themselves by an overdose.

For three years I have experimented with parrots, and know that what is said here is true, having got parrots that never tasted ordinary pure water in months of captivity and immediately bringing it before them. When every look and action asks for it in a mute appeal, as strong as any spoken language could convey.

Gradually, until thoroughly satisfied, they were given a few drops only at a time, in a spoon; and later, a basin large enough for them to bathe in, is always kept full of clean water, and their delight is plainly told in happy chatterings while bathing every day. These birds are clean, fat, and healthy, and bid fair to live as long as if free in their own natural condition and surroundings. If one wishes to know how the poor captive and interesting pet feels, let him try doing without the water a few days, and if that one possesses a parrot and any degree of humanity, the bird will get the desired and necessary water. Remember your own feelings and what the wise man and the poet says of a drink of water, and do not be so foolish and cruel as to keep your captive pet from Nature's drink. This custom is one widely diffused through the Spanish and Portuguese American countries as well as our own, and from a humane and Christian standpoint, as well as from that of a fellow feeling, should be stopped.

It seems to me that the experiment on "Milk as a Diet," reported in the issue of June 22, while very laudable, proves only what is already well known, and what any one, by simple observation, without ever reading a book or trying an experiment, should know. Milk, chemically and physiologically in a pure condition, contains all the elements of a typical diet. The young of almost all animals and all mammals, in a broad sense, demonstrate plainly that milk, and not bread, is the first essential of human and most animal life, and that all the science of man cannot make a food to compare to it, for without anything else whatever, they grow strong and fat upon it.

St. Joseph B. Graham, M.D.

Quarantine Station, Savannah, Ga.

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